Document of
The World Bank

Report No: 19130 CH

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED LEARNING AND INNOVATION LOAN (LIL)

IN THE AMOUNT OF US$5 MILLION

TO THE

REPUBLIC OF CHILE

FOR A

MILLENNIUM SCIENCE INITIATIVE PROJECT

April 1, 1999

Human and Social Development Group
Argentina, Chile and Uruguay Country Management Unit
Latin America and the Caribbean Regional Office

CURRENCY EQUIVALENTS
(Exchange Rate Effective 5/19/98)
Currency Unit = Chilean Peso (CLP)
452.55 CLP = US$1.00

FISCAL YEAR
July 1 to June 30

ABBREVIATIONS AND ACRONYMS

CONICYT	*Comisión Nacional de Investigación Científica y Tecnológica* (National Commission for Scientific and Technological Research)
ERC	Engineering Research Center
FONDECYT	*Fondo Nacional de Desarrollo Científico y Tecnológico* (National Fund for Scientific and Technological Development)
FONDEF	*Fondo de Fomento al Desarrollo Científico y Tecnológico* (Fund for the Promotion of Scientific and Technological Development for Industry-University Collaborative Research)
GDP	Gross Domestic Product
GNP	Gross National Product
IADB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development
ICR	Implementation Completion Report
ICB	International Competitive Bidding
IDA	International Development Association
ILB	International Limited Bidding
IMU	Implementation and Management Unit
IV PNCT	*Cuarto Programa Nacional de Cooperación Técnica* (Fourth Technical Assistance National Program)
LIL	Learning and Innovation Loan
M&E	Monitoring and Evaluation
MECESUP	*Proyecto de Mejoramiento de Calidad de Educación Superior*
MSI	Millennium Science Initiative
NCB	National Competitive Bidding
OECD	Organization for Economic Cooperation and Development
PAD	Project Appraisal Document
PPF	Project Preparation Facility
PPP	Purchasing Power Parity
R&D	Research and Development
S&E	Science and Engineering
S&T	Science and Technology
SI	Science Institute
SN	Science Nucleus
SOE	Statement of Expenditures
STC	Science and Technology Center
UNDP	United Nations Development Program
WDR	World Development Report

Vice President:	Shahid Javed Burki
Country Manager/Director:	Myrna Alexander
Sector Manager/Director:	Xavier Coll
Task Team Leader/Task Manager:	Lauritz Holm-Nielsen

Chile
Millennium Science Initiative Project

CONTENTS

Annexes

Chile
Millennium Science Initiative Project

Project Appraisal Document

Latin America and the Caribbean Regional Office
LCC7C

Date: March 19, 1999 | Team Leader: Lauritz Holm-Nielsen
Country Manager/Director: Myrna Alexander | Sector Manager/Director: Xavier Coll
Project ID: 63386
Lending Instrument: Learning and Innovation Loan | Poverty Targeted Intervention: [ ] Yes [X]

Project Financing Data [X] **Loan** [ ] **Credit**

For Loans/Credits/Others:

Amount (US$m): 5.0
Proposed terms: [ ] Multicurrency [X] Single currency, specify US$
Grace period (years): 3 [ ] Standard Variable [ ] Fixed [X] LIBOR-based
Years to maturity: 15
Commitment fee: 0.75%
Front end fee: 1.00%

Financing plan (US$m):

Source		Local	Foreign	Total
Government		10.00M	0.00M	10.00M
IBRD		0.00M	5.00M	5.00M
	Total	10.00M	5.00M	15.00M

Borrower: Republic of Chile
Guarantor: N/A
Responsible agency: Ministry of Planning

Estimated disbursements (Bank FY/US$M):	2000	2001
Annual	3.4	1.6
Cumulative	3.4	5.0

Project implementation period: 09/30/01 Expected effectiveness date: 10/01/99 Expected closing date: 03/31/02

A: Project Development Objective

1. Project development objective (see Annex 1):

As a Learning and Innovation Loan (LIL), this project has a specific objective related to learning, and a follow-on objective related to potential improvements in the sector which could come about if the LIL leads to successful follow-on activities.

The specific objective of this LIL is to demonstrate significantly improved performance in a highly selected segment of the Chilean S&T system. The LIL would help revitalize Chile's S&T system by *supporting advanced training of human capital by world-class scientists engaged in cutting edge research.* It would demonstrate the effectiveness of transparent, merit-based allocation procedures, and investigator autonomy in improving the quality and efficiency of scientific research and training. This demonstration is also expected to energize an R&D sector that is characterized by underperformance and excessive bureaucracy. It would (a) create pressure for adoption of the principles of transparency, merit-based allocation, and reward of productivity by the system as a whole; and (b) promote integration and partnership with more scientifically advanced countries, as well as with Chile's regional partners.

The LIL would partly finance a competitive fund that will support: (a) about 3 world-class research groups with investigator autonomy and adequate levels of longer-term funding; (b) about 10 emerging groups of high quality, with investigator autonomy and adequate levels of medium-term funding; (c) networking and outreach activities that spread the benefits of top-quality research to potential collaborators and benefactors, be they students, fellow researchers, and/or partners from business and industry. The LIL would be the initial phase of the project called "Millennium Science Initiative" (MSI). The groups described in (a) will be known as "Science Institutes" (SIs), and those in (b) as "Science Nuclei" (SN).

An important feature of the MSI would be the highly selective process for granting awards. This process would include participation of top-level international scientists, and would fund only researchers of world-class potential. A major objective of the project is to show that, under proper procedures, world-class scientific research can be conducted in Chile, and within Chile's S&T research budget.

The follow-on development objective is to revitalize the Chilean national innovation system by increasing the country's capacity to produce, gain access to, and adapt scientific and technological knowledge. In the longer term, as the follow-on activities are undertaken, the MSI is expected to contribute to increased productivity in Chile. More Ph.D. students would be trained at higher quality, increasing the cost-effectiveness of the training. More and higher quality scientific output is expected, some of which may have direct implications for industry. The cumulative effect of increases in both human capital and knowledge stocks would be to move Chile closer to parity with the world's more knowledge-based economies. These benefits are expected to accrue in the form of more knowledge-intensive goods and services and more highly qualified people working in the public and (especially) private sectors. As the more effective funding rules are adopted by the rest of the system, the benefits may be further amplified. (See "Annex 3: Assumptions and Expected Benefits" for an explanation of the dynamics of the national innovation system in Chile. Those assumptions form the basis of these expected benefits).

2. Key milestones and performance indicators (see Annex 1):

There are two important time frames to consider with respect to indicators: what can be achieved during the LIL phase and what can be achieved in the longer term, as the follow-on activities are undertaken. The MSI would be partially supported by the Learning and Innovation Loan from the World Bank for its initial two years. The Government of Chile intends to continue the initiative for at least 5-10 years, regardless of the source of financing.[1]

Many project benefits would not appear until after the LIL is closed. Therefore, the project will have two sets of indicators. The first set will measure benefits during the initial two year phase (under the LIL). These indicators will focus more on process, be largely qualitative, and summarize the *direct* learning that occurs under the project. The second set of indicators will measure output and impact over the ten year life span of the MSI, and focus on the *induced* learning by stakeholders throughout the Chilean system.

(1) The first set would examine:

(a) **Selection Process**: measure how fair, open, competitive, and merit-based the process is. Independent reviews by panels and opinion polls should indicate a significantly *greater confidence in the MSI award process than in other grant award processes.*

(b) **Administrative Efficiency**: should be faster, more flexible, and less burdensome. Response time in general, and *grant processing time for the IMU should be at least 50% faster than other research-funding institutions.* Opinion polls should indicate greater flexibility and autonomy.

(c) **Concentration of Resources**: grants per researcher totals should be on average within *33% of averages from selected OECD countries for corresponding disciplines.*

(d) **Perceptions Regarding "Stagnation"**: qualitative assessment should indicate if, and to what degree, the *MSI is perceived to facilitate high-level scientific research in Chile. Perceptions of better career opportunities,* more merit-based award decisions, less bureaucratic constraints, more adequate packages of resources would be measured through opinion polls.

(e) **Collaboration with International Scientists**: track/map the number and nature of additional international collaborations facilitated by the MSI. It is expected at least a *20% increase in the number of collaborations, accompanied by improved duration and quality.*

(f) **Human Capital Training Opportunities**: determine whether the MSI is contributing to increased Ph.D. enrollment in the sciences. One expects that MSI-funded researchers would train at least *50% more doctoral and post-doctoral students on average than their colleagues.* Additional data on the profile of students and post-docs will be gathered, to see whether the MSI is providing *opportunities for women and other individuals from previously underrepresented groups.*

[1] The 5 to 10 year time frame is critical, because world-class researchers will only participate in an endeavor that they credibly believe will continue long enough to do research, publish results, and receive recognition.

(2) The second set of indicators will measure the extent to which:

(a) **Use of International Standard Selection Procedures is Widespread**: A qualitative comparison would determine *whether other major funding programs in Chile adopt the transparent, merit-based procedures piloted under the MSI.*

(b) **Efficiency Gains are Generalized**: This indicator would determine *whether savings from light administration are realized and utilized by throughout the system.*

(c) **Research Productivity Increases**: The *quantity and quality of research output, as measured by publications, collaborations, citations, patents, graduates, and other scientometric measures*, improves for researchers associated with the MSI and in Chile as a whole.

(d) **Mobility of Researchers is Increased**: The perception of improved opportunities should accelerate the migration of top researchers to and from Chile. In the short term, this would be *measured by researcher attitudes and intentions to migrate to and from Chile, and in the medium term by actual migration.*

(e) **Labor Market Response Increases**: to the newly available human capital (measured in *increased employment for new Ph.D.s and postdocs*), especially in the private sector.

The ultimate performance indicator for this project would be a social or economic advance stemming directly from MSI-funded research. Such results normally appear only after 8-25 years depending on the discipline, and are affected by many outside factors. However, the direct research output would be followed in annual reports.

B: Strategic Context

1. Sector-related Country Assistance Strategy (CAS) goal supported by the LIL (see Annex 1):

CAS document number: 14370 Date of latest CAS discussion: May 9, 1995

This project would contribute to the sector-related Country Assistance Strategy (CAS) goal of "upgrading Chile's human capital, with a view towards improving the country competitiveness in the international arena" (para. 34). This LIL : (i) is expected to contribute to raising the quality and enlarging the stock of human capital contributing to the Chilean economy; (ii) has the potential to strongly and positively influence S&T policy in Chile; (iii) complements the other major Bank effort to improve advanced training and human capital formation: the Higher Education Improvement Project; and (iv) would be consistent with the Bank's desire to support efforts by countries to improve their integration into the world's knowledge base and knowledge production system. With respect to (iv) the effort may provide opportunities for "leapfrogging" and/or for the strategic use of knowledge for development, as outlined in the 1998 World Development Report (See Annex 3, "Assumptions and Expected Benefits").

2. Main sector issues and Government strategy:

Chile's scientific community garners well-deserved respect in the region and worldwide. The country has made significant and fruitful efforts to move toward a leadership position in research among industrializing countries. While progress has been substantial, it has not been sufficient for the country's aspirations and much remains to be done.

Main Sector Issues:

Despite relative strength in certain comparators with other Latin American countries (see Annex 11), the Chilean S&T system is constrained in ways that substantially hinder its performance: (i) major bottlenecks to advanced training keep Chile's supply of human resources for S&T insufficient for renewal and growth; (ii) resources for R&D are generally scarce and fragmented; (iii) funding and implementation procedures do not appropriately support good research output; and (iv) planning for the sector is weak and uncoordinated. Together, these factors perpetuate a system that is small (producing fewer than 50 new Ph.D.'s per year in science and engineering), inefficient, and isolated rather than integrated with other levels of university-based human resources training.

(i) Serious bottlenecks keep human resources training for S&T insufficient for renewal and growth

Most advanced countries have policies that encourage enrollment in Ph.D. and post-doctoral programs, especially in key S&T disciplines. Chile has the contrary; its current policies and practices tend to discourage enrollment. CONICYT does not support half of Ph.D. candidates who seek fellowships—even though all these candidates have already been deemed qualified and admitted to Ph.D. programs by university departments. CONICYT's policy for granting doctoral scholarships is, in general, centralized and lacking in flexibility. The principal investigators and senior scientists who will train the students have very little say in who is selected and for which programs. Non-Chilean residents are currently ineligible to receive support. With so many qualified candidates for advanced training turned away, understaffed laboratories, vastly lower and slower production of publications, and the inability to pursue fruitful areas of investigation have become commonplace.

As a result, the country produces fewer than 50 Ph.D.'s per year in science and engineering. Some of these go abroad as post-docs and do not return. Another 30 Chileans receive S&E doctoral degrees outside of Chile, but more than half of these remain abroad. In total, Chile is adding five to ten times fewer new Ph.D.'s per year to its R&D system than other countries with similar size populations, such as Greece or Taiwan, and twenty times fewer Ph.D.'s per capita than advanced OECD countries. The average age of a Chilean researcher is several years above the international average, and is increasing.

(ii) Scarce and fragmented resources

Standard FONDECYT grant amounts--with a few notable exceptions-- are less than US$ 30,000/ year, far below the levels which are generally accepted as adequate to allow a researcher to do high level work.[2] Low *de facto* ceilings for most equipment purchases limit the selection of useful research topics and therefore exclude Chilean scientists from working in advanced areas in many disciplines. As a result, many researchers can survive at a low-level, working on obsolete problems, but very few can prosper or flourish. The fragmentation is mostly the result of a weak culture of competition in the research community.

[2] These levels tend to vary greatly according to field, and there is no consensus on exactly how much is needed per year for effective research. Nonetheless, one can use US$ 250,000/year per investigator of total resources as a broad benchmark. Also, while some locally-available inputs may be cheaper in developing countries than in OECD countries (such as salaries for research assistants), any savings are usually more than offset by two conditions: (i) scientific equipment tends to be more expensive in developing countries than in developed ones, because volume of sales is lower; (ii) import tax exemptions are often not available for equipment, further driving up its cost. Furthermore, the capital stock of equipment will often be inadequate. As a result, it is generally accepted that it is at least as expensive, if not more so, to do scientific research in a developing country compared with a developed one.

Like many industrializing countries, Chile is caught in a double bind for scientific development: it seeks absolute growth in both the quantity and quality of research and researchers in its system. Quality improves most in a culture where the "creative destruction" of competition awards adequate resources to the best and deprives the unworthy of support. Industrializing countries increasingly appreciate the need to inculcate a culture of quality—and the trade-offs inherent therein—in order to get returns from their R&D investments. Experience shows that an S&T policy which does not raise the bar for quality before attempting to expand quantity generally leads to a costly, inefficient R&D community with no dynamism.

As a corollary, Chile's small research community, like that of many developing countries, gets trapped initially in a cycle of conflict-of-interest when it attempts to adopt OECD-style allocation procedures (competitive funding, anonymous peer review). The presence of top-level international scientists in the MSI would help Chile "leapfrog" out of this cycle—an achievement which has taken 15 years (and continuous Bank support) in Brazil.

(iii) Rules and procedures that hinder good research output

In addition to scarce resources, a variety of bureaucratic rules and procedures significantly diminish researcher effectiveness. These routinely introduce unnecessary delays, and/or impose arbitrary restrictions on researchers. Decisions over awarding and using research funds are determined by this bureaucratic legacy, rather than the judgment of the investigator. For example, a large program to promote joint research only supports teams from the same departments within a single university—collaborations among different universities or faculties are not eligible. Another rule mandates collaboration with industry for all disciplines—leading researchers to construct artificial and unproductive ("for show") alliances to satisfy a bureaucratic requirement for access to funds. Investigators awarded "infrastructure" grants cannot simultaneously hold the "project" grants that would allow them to make use of the infrastructure.

(iv) *Insufficient long-term planning for, and commitment to, high quality scientific research*

The current situation has evolved because S&T policy historically has not been coordinated. The responsibility for making policy is not clearly assigned to any agency or institution. As a result, the Government's strategy has tended to respond to individual issues with individual program initiatives. This has led to a patchwork of programs and policies, some of which may be effective in isolation, but which does not add up to a supportive environment for research. CONICYT was created to assist and advise the President of Chile on policies regarding the scientific and technological development of the nation, but in practice its role in policy making is at present very limited.

As a result of the above-described situations, researchers and policy-makers report a general perception of system in stagnation. The combined effects have created a malaise that traps the system in a cycle of underperformance.

Government Strategy:

The ultimate goal of the Government is the overall improvement of the S&T system, with the concomitant social and economic impact. An explicit choice has been made by the Chilean government to seek this through a demonstration project, rather than by directly attempting a comprehensive reform of CONICYT.

Such a comprehensive reform of CONICYT would change existing rules and practices in order to further promote a culture of competition and anonymous peer review. It would coordinate and rationalize training and research policies, assure adequate funding for top quality research, consolidate dispersed funding programs, increase the relevance (and hence the absorption of) graduate Ph.D.'s by the private sector, and further Chile's integration as a contributing partner in the world scientific community. This approach was rejected because key agencies lack the mandate and desire to undertake the type of system-wide reform that would be ideal. The potential losers from such a reform contend that the system cannot perform much better than it currently does. More importantly, they contend that the problem is a simple lack of resources rather than a lack of quality or productivity by researchers. In short, without a demonstration of better results in Chile under better rules, there is no pressure for change on the most intransigent parts of the current system.

The general strategy of the government is instead to energize the most capable parts of the system, and, through this demonstration of excellence, to create new models and mechanisms that can be adopted by other funding agencies in the S&T system. This demonstration effect may also have implications for positive changes in the S&T legal framework. The Initiative is a high priority for the Chilean government, which convened a workshop on the importance of science and technology for national and regional economic development. ["Realizing the Globalization of Discovery" Santiago de Chile, 1998: The Report from the International Advisory Group on Science and Technology]. The participants, among whom were the ministers of science and technology of some important MERCOSUR nations and top-level experts from the international science community, endorsed an effort to immediately move research in the region closer to international levels--through targeted interventions. The Government of Chile requested that a Bank-supported operation be developed in the shortest feasible time frame. The Government intends to support the MSI for an initial period of 5-10 years, during which time it will be thoroughly monitored, evaluated, and amended in accordance with the lessons of the learning experience.

3. Learning and development issues to be addressed by the LIL

The LIL will directly address issues (ii) and (iii) in section B.2. It pilots an improved selection and administration process, and it will concentrate rather than fragment resources through adequate-sized grants. The project will indirectly address issue (i) --bottlenecks to human resource development--in that MSI-funded researchers will aim to have fully-staffed labs, and train Ph.D. students in the same quantities as their counterparts in OECD countries.

A recent OECD review of best practice S&T policy states that "technological change drives long term economic growth, productivity, and improvement in living standards."[Technology, Productivity, and Job Creation: Best Policy Practices (Highlights) OECD, 1998, p.3]. The 1998/99 World Development Report observes that "knowledge has become perhaps the most important factor in determining standard of living." [p.16] The WDR further emphasizes the imperative for developing countries to close the knowledge gap, and strongly recommends that they develop national knowledge strategies for this purpose. Chile is attempting to do this, and this LIL would pilot a new structure for creation and adaptation of knowledge through advanced research.

The LIL would address how and to what extent such an investment in improving the quality of knowledge production can energize Chile's innovation system and help realize potential social and economic benefits [See Annex 3: "Assumptions and Expected Benefits"].

Appropriateness of the LIL format: The LIL format was designed to test, inter alia, "uncharted but promising territory for which viable technical, financial, social, and environmental solutions are not yet known." ["Adaptable Lending—New Investment Instruments: Report from the President" August 14, 1997, para. 18]. For this project, a small, controlled experiment in improving research quality would be piloted. It is expected that the learning outcomes would be closely analyzed and incorporated into a comprehensive reform for the S&T sector. As noted earlier, it is crucial to raise the level of quality within the sector before attempting a general reform, and the LIL format is designed for this type of pilot.

In addition, the LIL is suitable for what may be a regional or global network of centers of excellence for scientific research. Dialogue has begun with Chile's MERCOSUR neighbors on Bank support for such a network, as per the endorsement this idea received in June from representatives of Argentina, Brazil, and Chile. At the same time, internal dialogue is underway in the Bank to pilot the MSI idea in Romania, Hungary, the Philippines, Vietnam, Colombia and Mexico. Currently, the nature of the interconnections and networking between MSIs in different countries and regions is not defined. Furthermore, the LIL instrument is designed to potentially be "clustered in a particular sector ...[and]...similarly, there may be regional issues which need a regional approach....a regional facility could be established to respond to specific development issues and individual LILs taken up by participating borrowing countries." [ibid., para. 28]. Therefore, the LIL is the most appropriate vehicle for testing and learning about this element of national strategies for closing the "Knowledge Gap."

4. Learning and innovation expectations

The LIL pilots a means of improving the National Innovation System that can be expected to move Chile toward a more knowledge-based economy in the long term. Many of the benefits (such as higher quality human resources and new products and processes) have long gestation periods and require a sustained investment in knowledge creation; these are not expected to appear during the implementation of the LIL. Others would appear or begin to appear during implementation. Therefore, as mentioned in section A.2 (Key Milestones and Performance Indicators, p.5), learning expectations—and the indicators used to measure them—will be divided into:

- *Direct*: to appear under the project and may involve mostly attitudinal change.
- *Induced*: to appear mostly in the follow-on phase; involve mostly behavioral change.

a) Economic: There are economic consequences to all the proposed improvements to be piloted (efficiency in selection and administration, improved working conditions, and increased training for young people) but, in the short term, one can expect to learn most about the consequences of **concentration of resources**. The supposition is that money is being fragmented into parcels that are too small to lead to world class research output, and that the most productive researchers are being deprived of the resources they need to work properly.

In the longer term, one expects to learn about the impact of the project on economic productivity, mostly through **labor market responses** to those trained in connection with the funded research. One also expects to learn if more collaboration between firms and public sector (university-based) researchers, and if more research output would be commercialized. The supposition is that the skills gained through research would produce knowledge that can be translated into goods and services.

b) Financial: In the short term, one expects to learn whether improved **administrative efficiency** makes investigators more productive. This will depend, inter alia, on the effectiveness of ex-post audits versus restrictive ex-ante controls. Clear international benchmarks on the speed, efficiency, and effectiveness of science administration institutions exist, and the IMU would be measured against these. These benchmarks deal primarily with the percentage of overall funding spent on administration, and the speed and efficiency with which resources are passed to researchers.

c) Technical: The key technical learning issues is whether presence of high-level international scientists in the **selection process**, and more open and merit-based selection criteria would create a system that functions at the level of the best international systems (generally from OECD countries). Much of the effectiveness of the best systems come from the knowledge—and the strict adherence to the highest procedural standards--embodied in the people who comprise it. The supposition is that lack of such people in the selection processes in countries like Chile is a key constraint, and that inserting them would catalyze improved research performance.

d) Institutional: In the short term, the institutional learning issues relates to the extent to which the new mechanisms (MSI Directorate: Board of Directors, Program Committee, and IMU) are perceived as improvements and thereby diminish **perceptions of stagnation** with Chile's R&D system. Also, one expects to learn the role and importance of other institutions—such as universities—in the R&D system in contributing to the malaise. It is possible that the MSI will function well, but that the project success could be frustrated at the level of the research institutions. This might occur through stakeholder resistance to change, or simply through the influence of inflexible bureaucracies. It should be noted that measures have been taken to prevent such institutional interference: grantees may establish themselves as legally independent entities

In the long term, one expects to learn to what extent institutions adopt improved procedures introduced by the project. This would occur through a type of social learning, discussed in section (e) below.

e) Social: Two major learning areas will be examined in the social realm: (a) the extent to which the MSI produces new collaboration; and (b) the extent to which it opens new opportunities for women and for members of other groups that are traditionally under-represented in science worldwide.

With respect to (a), several new types of **collaboration** are expected. First, between Chilean scientists and their regional partners, due to higher recognition they would receive as MSI researchers. Second, between Chilean and other international scientists, again through their higher recognition under the MSI, as well as via international dissemination catalyzed by the participation of high-level international scientists in the selection process. Third, increased numbers of non-Chilean graduate students are expected, both via special regional scholarships designed to attract the best young brains in the region (especially from Argentina and Brazil), and in general, due to the high quality of the work. One measure of success would be the extent to which students from OECD countries, who traditionally choose Europe and North America for their training, would be attracted to Chile.

With respect to (b), information will be gathered under the project on the **profile of students seeking advanced training in S&T disciplines**. This will include a host of varied information, among which will be socio-economic background. As part of the analysis, an examination will be made of the participation of **women and other groups that are traditionally under-represented in science**. The data will be collected by or under the supervision of the IMU.

[Note: informal studies and anecdotal evidence suggest that, while there is under-representation of certain groups in science in Chile, participation levels are similar to those of OECD countries.]

Finally, in the area of social learning and innovations, one could classify the expected influence of "demonstration effect" of the MSI as a type of social learning. This phenomenon occurs when the introduction of fair and open competition for resources, merit-based awards and recognition, rational and efficient administration, creates an intolerance for the traditional, less efficient means of awarding and administering research grants. The intolerance in turn creates pressure for change, and eventually change itself. Thus, the poorer performing system is driven out by a better performing one. This type of social learning has occurred in Brazil, and, to a lesser extent, in Mexico, under Bank-supported S&T projects. If successful, the changes should stimulate scientist to return to or remain in Chile, reversing the current brain drain.

C: Project Description Summary

1. Project components (see Annex 2 for a detailed description, Annex 1 for inputs, and Annex 4 for a detailed cost breakdown):

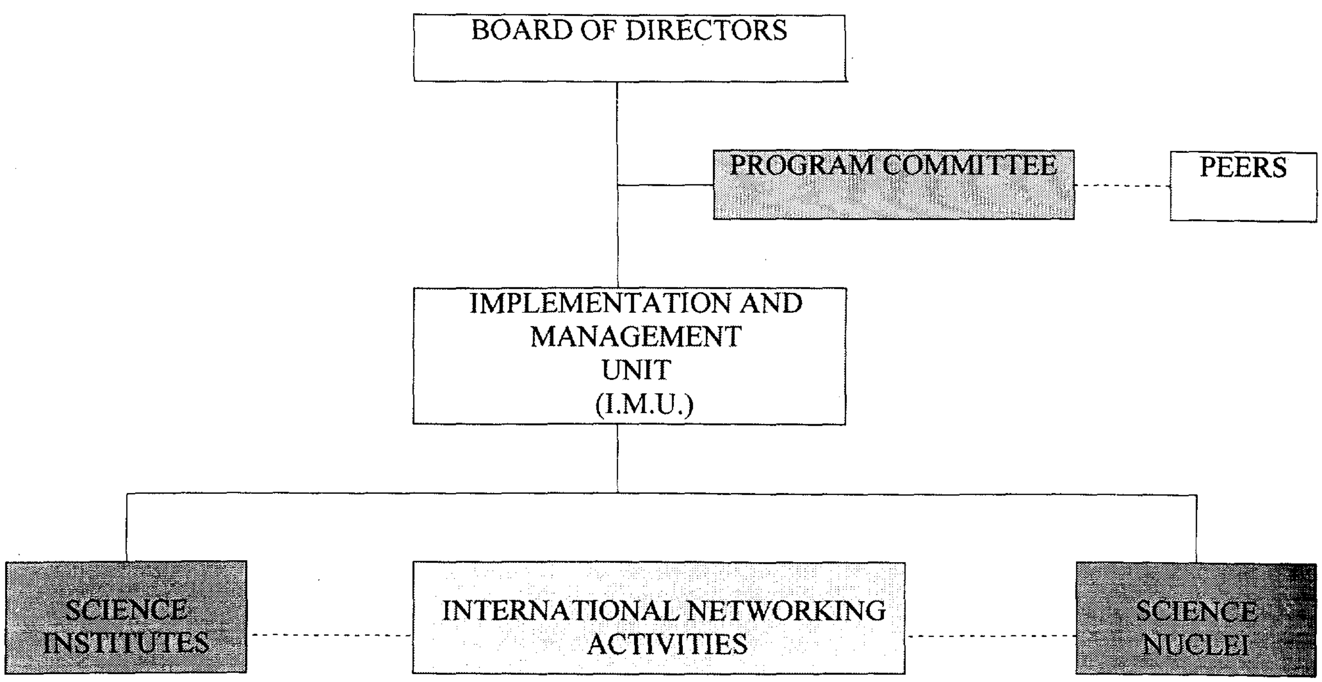
Component	Sector	Indicative Cost (US$M)	% of Total	Bank-financing (US$M)	% of Bank-financing
1. Management Structure for the Millennium Science Initiative Establishment and operations of Board of Directors, Program Committee and Implementation and Management Unit; technical assistance for selection of Science Institutes and Nuclei; development of a proposal to improve the S&T institutional framework; M&E studies	Institution building, project management	1.000	6%	0.500	10%
2. Competitive Fund for Scientific Excellence Funding of research projects at about 3 Science Institutes and about 10 Science Nuclei	Institution building, physical investments	12.000	80%	3.475	69%
3. Network for the promotion of Scientific Excellence Funding of visits, exchange programs for researchers, post-docs and graduate students, design and delivery of international advanced courses, dissemination of lessons learned	Institution building	1.500	10%	0.750	15%
Physical and Price Contingencies		0.450	3%	0.225	5%
Total		**14.950**	**99%**	**4.950**	**99%**
Front-end fee		0.050	1%	0.050	1%
Total Financing Required		15.000	100%	**5.000**	**100%**

2. Institutional and implementation arrangements:

Implementation period: The Project would be implemented over two years, as the first phase of the five to ten-year Millennium Science Initiative. During the first 6 months, the Board of Directors and Program Committee would be created, selected and/or seated, the grant selection process would take place, and the grant contracts would be signed. During the remaining 18 months, awards would be disbursed, research conducted, the project networking and outreach activities would be implemented, and a second round of grant awards would be made.

Implementing arrangements: A small administrative structure, attached to the Ministry of Planning (MIDEPLAN), would implement the MSI. The structure would be comprised by: (i) a Board of Directors, appointed by the President of the Republic, would provide broad management oversight; (ii) a Program Committee, composed of six distinguished scientists of international stature, would direct and execute the grant award selection process and other activities that require scientific expertise; (iii) an Implementation and Management Unit (IMU), composed by an Executive Director and a small administrative staff. (See PIP and Project Description, Annex 2). The IMU would have responsibility for all day to day administration of the selection process, grant contracting, and grant management. Procurement would be decentralized, with most decisions and actions taken by research Institutes and Nuclei, but under the supervision and aegis of IMU.

BASIC ORGANOGRAM OF THE MILLENNIUM SCIENCE INITIATIVE



Financial management and auditing: A Bank Financial Management Specialist (FMS) visited the Implementation and Management Unit (IMU) to carry out the financial management assessment required under Bank policy. The FMS discussed and explained to the Project Coordinator and to the Administrative Manager at MIDEPLAN, Bank policies and procedures regarding project financial management, including accounting, reporting, project monitoring and audit. IMU staffing arrangements are being completed and a Consultant's report on the required accounting system for the project was reviewed by the Bank. The IMU will have implemented a time-bound action plan acceptable to the Bank for strengthening the project financial management system not later than 12/31/99. The action plan will include measures to complement the prevailing financial controls at MIDEPLAN, entity through which project resources would be channeled to the SIs and SN. In addition, the IMU will hire a consultant to develop a system for Project Management Reports (PMRs). Institutes and Nuclei would retain supporting documentation for expenditures made under grant agreements. The external audit would be contracted with an independent auditing firm acceptable to the Bank and carried out in accordance with terms of reference provided by the Bank. Yearly financial audit reports will be furnished to the Bank within six months from the end of each fiscal year.

3. Monitoring and evaluation arrangements:

Monitoring and Evaluation: The IMU would be responsible for coordinating M&E activities, under the guidance and oversight of the Program Committee, where appropriate. They would monitor both the conduct and output of the funded research and related data from the project and S&T sector as a whole. The main M&E tasks would be: (a) to establish the baseline data for both long- and short-term indicators; (b) to collect information and data as required on the project and the R&D system as a whole [See Indicators in Annex 1]; (c) to liaise with the Program Committee and oversee any special studies or M&E activities contracted to consultants; and (d) coordinate and facilitate the work and site visits of the panels that conduct the annual external evaluations.

Annual Progress Reports for Grantees: The director or principal investigator of each SI and SN would prepare an annual report prior to March 30 of each calendar year. These reports would contain a self-evaluation on the implementation progress of the research, the scientific results and their dissemination and impact, the progress of the training of students and post-docs, and the extent, nature, and success of the network and outreach activities.

External Evaluations: During the learning phase of the MSI, a small team of independent reviewers would visit Chile for one week to make an evaluation report on the progress of all project components. The evaluation report would be ready prior to May 30 of each calendar year. The panelist would conduct brief site visits to all subprojects. Prior to their visit, the panelists would review the annual reports from all SIs and SN, plus any other relevant M&E data produce by the IMU or its consultants. The panelists would conclude the week by producing a report evaluating, inter alia, the scientific, economic, financial and cost/effectiveness aspects of the project. The purpose of these evaluations would be to subject the Project's own M&E data and conclusions to outside scrutiny, to gain the independent view of impact, and to summarize lessons learned. The visit in year 2000 would be done by three panelists, and have the character of a mid-term review. The specific purpose of this review would be to gather all relevant experience from the first year of operation—in the context of international comparison—to provide the Government of Chile and the World Bank with detailed recommendations. In particular, the Midterm evaluation would review the establishment of the Management Structure of the Initiative, the selection process of the Institutes and Nuclei, and the initiation of research and training activities at Institutes and Nuclei. This evaluation would identify bottlenecks in the administrative process, including organizational, disbursement, procurement, and financial management procedures. The Government would subsequently decide on how to continue the next phase of the MSI. The visit in year 2001 would have 5 panelists and serve as input into the Implementation Completion Report (ICR) for the project. Panelists would generally be non-Chileans with extensive experience in research funding and science policy. Peer reviewers of subprojects may serve as review panelists, if appropriate.

Consolidation of Evaluations into the Program Committee's Annual Report. The Program Committee would generate annual reports (by June 30 of each calendar year) integrating the results of all monitoring and evaluation activities, plus its own evaluation of project progress. These may contain recommendations for policy changes and mid-course corrections, subject to Bank approval (the annual reports will be reviewed with the Bank by August 30 of each calendar year). Data related to the sector as a whole would be collected either by the IMU or through targeted studies commissioned by the Program Committee.

D: Summary Project Analyses

1. *Economic Analysis*: No formal economic analysis was conducted, as per the LIL format. The supposition that investments in science capacity and R&D are appropriate is supported by ample evidence (see Annexes 5 and 3). Rather than a cost-benefit justification, an analysis has focused on why an investment in improved quality is appropriate and cost-effective.

This small scale pilot investment in quality is a cost effective approach to reform under Chile's circumstances. Any investment in reform of S&T systems in developing countries must seek two goals: (a) absolute growth in both the quantity of research and number of researchers; and (b) significant quality and efficiency gains. These two goals conflict to some extent, because quality improves most in a culture where the "creative destruction" of competition awards adequate resources to the best and deprives the less worthy of support. On the other hand, to increase the quantity of research and researchers requires a liberal funding policy and incentives to attract more individuals. The best solution is to attempt to improve quality and efficiency through improved selection and administration procedures in such a way that more promising young researchers are clustered around the best of the experienced researchers. This should be done prior to making large scale investments in the sector. Experience shows that an S&T policy which does not raise the bar for quality before attempting to expand quantity generally leads to a costly, inefficient R&D community with no dynamism.

Improved administrative procedures should lead to efficiency gains that increase the cost-effectiveness of the investment.

The major alternative to this type of investment in science funding processes has been to invest in infrastructure. However, even a much larger investment than the US$15 million here contemplated (representing only 2% of public sector investment in R&D) would not be effective unless selection (allocation) and administrative rules were changed. Even under this scenario, the impact of the LIL would be greater because it focuses on the country's best researchers, those who set the standards for scientific conduct within Chile. [See also Annex 5.]

2. *Financial Analysis*: All projects under the MSI would be non-revenue generating projects.

The expected fiscal impact of the initiative, which would have the support of the Government of Chile for a five to ten year time period, is as follows: World Bank financing under the LIL is proposed for the first two year phase. During this period, the expected counterpart contribution is an average of US$ 5.0 million/per year, or less than 1.5% of the $375 million spent annually by the public sector on R&D. In the follow-on phase (years 3-10), the Chilean Government may assume complete responsibility for financing the MSI. This would represent less than a 4% increment in its R&D financing commitments.

3. *Technical Analysis:* Clearly it is not possible to evaluate ex-ante the technical strengths of the research to be conducted, since this will only be revealed in the selection process. From visits to

laboratory facilities, it was confirmed a fortiori the previous diagnosis of the state of science research in Chile. Specifically, it was observed and concluded that a sufficient supply of candidates exists for a centers of excellence program. Potential candidates were defined as investigators who have the capacity--under the appropriate conditions--to conduct research and training at the very highest level of international standards for their discipline or subdiscipline. The human potential exists, and the infrastructure for research can operate at the high level envisioned by the project.

A principal technical challenge will be securing the participation of a group of high-level international scientists to form the Program Committee. Such individuals would have extensive experience in the process of selection and administration of research projects, as researchers, peer reviewers, committee members, and administrators. The project includes a process through which the best candidates worldwide for these positions would be identified and recruited to participate. The technical opinion of the preparation team is that this process is sound and will achieve its goal.

4. Institutional assessment: The projects would pilot a light model of administration under which a high-level Program Committee provides the conceptual and substantive direction to the project, including selection of the projects for funding. A small Implementation and Management Unit (IMU, with 3-4 full-time equivalents) would handle all aspects of project administration and monitoring. This group would include the Executive Director, who will liaise with the Program Committee as needed. This proposed structure (Board of Directors, Program Committee, and IMU) is one option for implementing the project and it has been deemed acceptable. The complete institutional arrangements are described in section C.2 and Annex 2.

The assessment of the Bank Team was that the current conditions at CONICYT would not be favorable for piloting such an entity. CONICYT, by charter and tradition, operates under a set of rules and practices that are not conducive to rapid and efficient ("light model") administration. The proposed LIL would also provide technical assistance to develop a proposal to improve the S&T institutional framework. This proposal would be implemented during the eventual follow-on project.

5. Social Assessment: The possibility exists that researchers who do not win awards under the MSI would actively resist attempts to generalize its improvements to the system as a whole [See risks section]. By the same token, evidence suggests that stakeholders in key institutions may adopt MSI-type procedures early, to appear on equal footing with this high-profile project.

6. Environmental assessment: Environmental Category [ ] A [ ] B [X] C
The project is not expected to have any significant impact on the environment. The SIs and SN will adhere to standards for environmentally-sound laboratory safety practices and disposal of hazardous materials acceptable to the Bank and included in the Operational Manual.

7. Participatory approach:

a. Primary beneficiaries and other affected groups:

Consultations were carried out with the main stakeholders of the S&T sector, including University rectors, and representatives of CONICYT, the Ministry of Finance, *Fundación Chile*, private foundations, and research groups. All stakeholders were, in general, supportive of the initiative. There was agreement that the initiative should be highly innovative, complementary to existing CONICYT programs and well articulated with the Higher Education and S&T systems.

b. Other key stakeholders:

The concept has also been discussed widely with scientists and science administrators from neighboring countries, the international community, as well as with representatives of technology-intensive firms. Levels of enthusiasm for the project are high among these groups.

E: Risks

1. Critical Risks (reflecting assumptions in the fourth column of Annex 1):

Risk	Risk Rating	Risk Minimization Measure
Lack of commitment to continue funding over the long term	M	Government's intention to continue the MSI for 5-10 years, provided a favorable evaluation
Universities might view the initiative as preferential treatment for a select few from which they gain nothing.	S	The institutes/nuclei will be integrated into the existing system in such a way as they are seen as beneficial to the system as a whole, and they provide access to scarce and costly equipment for qualified non-participants.
The initiative could be viewed as subtraction or deviation from other research and teaching priorities.	M	The funding structure should eliminate or minimize this risk.
Overall Risk Rating	M	

Risk Rating - H (High Risk), S (Substantial Risk), M (Modest Risk), N (Negligible or Low Risk)

F: Main Loan Conditions

1. Effectiveness Conditions:

(i) Presidential Decree establishing the Board of Directors and the Program Committee
(ii) Appointment of the Financial Manager for the IMU and employment of a consultant to develop a system for Project Management Reports (PMRs)
(iii) Operational Manual for the Chilean Millennium Science Initiative issued by MIDEPLAN and approved by the Bank

G: Readiness for Implementation

[ ] The procurement documents for the first year's activities are complete and ready for the start of project implementation.
[X] The LIL's implementation plan has been appraised and found to be realistic and of satisfactory quality.
[X] The following items are lacking and are discussed under loan conditions (Section G):
(i) Procurement Plan for the first six months of operations
(ii) Standard National Competitive Bidding Documents (to be included as part of the Operational Manual)

H: Compliance with Bank Policies
[X] This project complies with all applicable Bank policies.

Country Director: Myrna Alexander

Sector Director: Xavier Coll

Task Team Leader: Lauritz Holm-Nielsen

Annex 1
Millennium Science Initiative Project
Project Design Summary

Hierarchy of Objectives	Key Performance Indicators and Milestones	Monitoring and Evaluation	Critical Assumptions
Sector-related CAS Goal: "objective of upgrading Chile's human capital, with a view towards improving the country's competitiveness in the international arena"	**Sector Indicators:** • More commercially-viable new products and processes (number of patents issued) • Advances in the social arena (public health, environment, nutrition, etc) through increased capacity to create, select, and adapt knowledge	• National, World Bank, and IMF Data • Sector specific data	**(from Goal to Bank Mission)**
Follow-on Development Objective: To revitalize the Chilean National Innovation System, characterized by: • Widespread Use of International Standard R&D Selection Procedures • Generalized Efficiency Gains • Increased Research Productivity • Increased Mobility of Researchers • Increased Labor Market Response	• Operating practices of other programs increase the use of int'l procedures • Percentage of savings realized from light administration and utilized by the system • Increased quantity and quality of research outputs • Researcher attitudes and intentions to migrate to and from Chile (short-term); actual migration (medium-term) • Increased employment of doctoral graduates and postdocs in the private sector	• Independent panel's qualitative review • IMU's benchmarking and opinion surveys • IMU data • Tracer studies of research collaboration and migration • Tracer study of researcher employment patterns	• Increased use of advanced human capital and innovations by the productive sector
Project Development Objective: Demonstrate significantly improved performance in a segment of the Chilean R&D system, in the following dimensions: • Selection Process • Administrative Efficiency • Concentration of Resources for Researchers • Perceptions Regarding "Stagnation" • Collaboration with International Scientists • Human Capital Training	**Outcome / Impact Indicators:** • Majority of surveyed scientists (winners and losers) rank MSI as fairest funding source • Grant processing time 50% faster than other research-funding institutions • Grants within 33% of OECD average for corresponding disciplines/programs • Surveyed scientists perceive positive change in working conditions and career possibilities • 20% increase in the number of collaborations, accompanied by improved duration and quality • 50% more Ph.D.s and postdocs are trained by MSI-funded researchers • increased participation of women	**Project Reports:** In combination, for all indicators in this category: • ICR • Independent Panel Evaluation Reports, • Program Committee Self-Evaluation • Grantee's Annual Reports • Sample surveys of researchers' attitudes • IMU data	**(from Objective to Goal)** • Demonstration of the improved model for research funding, piloted under the LIL, is adopted generally • The selected grantees perform at the level of their colleagues in the world's scientifically advanced countries

Opportunities	in science		
Output for each component: • Light Administration Structure • Three Science Institutes and Ten Science Nuclei Consolidated • A Regional Network for the Promotion of Scientific Excellence Established	**Output Indicators:** • Calls for proposals according to procedures in years 1999 and 2000 • Research results and individuals in training in Institutes and Nuclei • 12 doctoral students or post-docs from neighboring countries trained under MSI fellowships	**Project Reports:** • ICR • Independent panel review, program committee self-evaluation • Grantee's Annual progress reports, independent panel assessment • IMU-gathered data; independent panel's qualitative evaluation	**(from Outputs to Objective)** • The Initiative is articulated with the Chilean, regional, and international S&T systems
Project Components/Sub-components: **1. Management Structure for the Millennium Science Initiative**: a) *Establishment of the MSI Directorate*: (i) Board of Directors; (ii) Program Committee; and (iii) Implementation and Management Unit b) *Selection of Science Institutes and Nuclei*: (i) Development and publication of the guidelines to call for proposals; and (ii) Pre-selection and selection of proposals by the Program Committee, assisted by int'l peers, and according to the developed criteria c) *Studies*: (i) Proposal to scale-up and institutionalize the project; and (ii) M&E **2. Competitive Fund for Scientific Excellence:** *Support for SIs and SN to conduct research, human resources formation and outreach activities* **3. Network for the promotion of scientific excellence:** (i) Visits to establish formal and informal connections to top centers and institutions; (ii) Exchange programs for researchers, post-docs, and graduate students; (iii) International advanced courses ; and (iv) Dissemination	**Inputs: (budget for each component)** • Remuneration and Administrative Costs; publications (US$ 1.0 million) • Cutting-edge scientific equipment • Infrastructure rehabilitation • Fellowships for doctoral students and postdocs (US$12.0 million) • Fellowships for researchers, students and postdocs in exchange programs (US$ 1.5 million)	**Project Reports:** • Disbursement reports (quarterly) • Supervision missions (annually)	**(from Components to Outputs)** • Universities clearly benefit from the Initiative • Budget line established in *Ley de Presupuesto* • Fresh resources are used to fund the Initiative

Annex 2
Millennium Science Initiative Project
Project Description

The project will have three components: (i) a compact management structure for the Initiative as a whole, the MSI Directorate; (ii) a competitive fund for grant awards to a highly-selected group of scientists; (iii) a network for the promotion of scientific excellence.

Project Component 1 - US$ 1.5 million (total cost of component)

Management Structure (the MSI Directorate):

This component includes the following: (i) establishment and operations of Board of Directors, Program Committee and Implementation and Management Unit; (ii) technical assistance for selection of Science Institutes and Science Nuclei; (iii) proposal to scale-up and institutionalize the project; and (iv) Monitoring and Evaluation studies. Under this component, the program would finance studies, publications, remuneration of Program Committee and IMU's personnel, and administrative costs.

The *Board of Directors* would be appointed by the President of the Republic and would consist of distinguished individuals interested in the advancement of science from the scientific community, academia, the business world, or public life. The Board would renew at least a third of its membership every five years. Term of office is five years for initial members, and two years for new members, renewable for two-year periods. The function of this high level board is to oversee the project and the implementation of the programmatic activities selected by the program committee. The Director of the Millennium Science Initiative would be appointed by the President of the Republic and chair the Board of Directors.

The *Program Committee* would consist of 5 distinguished international scientists of high stature, selected initially by the President's Science Advisory Council from a list of 10 to 15 names solicited from distinguished bodies such as the Nobel Committee, the European Science Foundation and the US National Academy of Sciences. One committee member would be selected as its chair. The function of this committee is to select from among the proposals submitted in response to widely distributed and transparent calls-for-proposals for activities funded by the Institute. In this process, the committee would use inputs from expert international peer reviewers.

The *Implementation Management and Unit* would be headed by an Executive Director and would perform all necessary support activities, including dissemination of calls-for-proposals, receiving the resulting submissions, submitting these to the program committee for selection of peer reviewers, and assisting in the notification and implementation of awards.

Project Component 2 - US$ 12.0 million (total cost of component)

Competitive Fund for Scientific Excellence:
This component consists on the funding of research projects at 1-3 Science Institutes and 5-10 Science Nuclei. The SIs and SN would carry out the following activities: (i) scientific research (ii) expansion doctoral and post-doctoral training programs/opportunities; (iii) networking, outreach[3]; and special activities to promote scientific excellence. Under this component, the program would finance cutting-edge scientific equipment, infrastructure rehabilitation (including laboratories), fellowships for doctoral and post-doctoral students, and publications.

[3] Each Millennium Institute must reach out to and interact with other entities, be they in industry, or in the education and social sectors.

The research proposals will be subject to pre-election and selection by the Program Committee, assisted by international peers, and according to the developed criteria. The resources requested in each application should be appropriate for achieving its goals, and may include state-of-the-art scientific equipment and its maintenance, chemicals and supplies, graduate student and postdoctoral fellowships under the control of the investigators, funds for national and international travel and cooperation, and other necessary funds. The proposals should be analyzed on the basis of their scientific excellence and the ability and track records of the principal and co-investigators. In accordance with standard international practice, the funding for all these components should be considered in the review process, so that the investigators do not have to apply to different sources of funds for the different elements of the proposal. The criteria for selection of the applications for an institute or center should include:

- The number of major investigators. At least 3 and preferably more should be involved
- The qualifications of the principal and co-investigators
- The excellence of the proposed research
- The utilization and training of graduate students and post-doctoral fellows

In addition, at least one of the following criteria should be considered:

- Proposed regional outreach activities
- Relation to societal needs such as environment, health or utilization of natural resources
- Connection to industry

Some specifics for the Science Institutes and Nuclei are as follows:

Science Institutes (about three initially), composed of Chilean scientists of international stature performing synergistic work in one or more cutting edge fields. One scientist from each center would be that center's head. The resources made available for the centers would be commensurate with the research to be performed (as described in the selected grant proposals) and with levels received by analogous groups internationally. These centers are expected to be able to compete scientifically in the highest level international arena. Requests for short preliminary proposals for these centers would be generated by the Program Committee and would spell out transparent rules of open competition for the available resources. The range, size, and parameters chosen for these available resources would be described in the request-for-proposals. The Program Committee would prepare a short list of proposals; the principal investigators would be invited to submit full (significantly more detailed) proposals. The full proposals would each be reviewed by at least three international peer reviewers, who are to be selected by the Program Committee. The Program Committee would then select awardees on the basis of these reviewers' recommendations. Science Institutes would be supported for five-year renewable periods, subject to satisfactory performance.

Science Nuclei (about 10), each comprised of promising scientists with the potential to evolve into researchers of the stature of those supported under the centers of excellence grants. The corresponding requests-for-proposals would likewise be generated by the Program Committee (through a similar process), and evaluated under similar procedures. The amount of resources for research nuclei would be smaller, the resource parameters narrower, and the selection criteria less extensive than those for the centers of excellence. Nonetheless, the merit of the proposals and the quality of the proponents would be of central importance--just as it would be for the centers. The nuclei for scientific research would be supported for one, non-renewable three year period.

Project Component 3 - US$ 1.5 million (total cost of component)

Network for the Promotion of Scientific Excellence:

Networking activities include: (i) research visits to establish formal and informal connections to top centers and institutions; (ii) coordination of appropriate Initiative-wide activities with Directors of SIs, SN, and principal investigators; (iii) programs for exchange of researchers, post-graduate, and graduate students; (iv) design and delivery of international advanced courses; and (v) dissemination of lessons learned. Under this component, the program would finance remuneration for researchers, fellowships for doctoral and post-doctoral students, travel expenditures, and publications.

With respect to possible regional cooperation, the Government of Chile has expressed its intention to keep Argentina, Brazil and Colombia informed about the MSI, and consider formal or informal collaboration during the lifetime of the project. Such collaboration could stand to prevent unnecessary duplication of research efforts and lead to more efficient use of S&T resources in all countries concerned. It might also lead to agreement to share certain oversight structures, such as a single international advisory board.

Annex 3:
Assumptions and Expected Benefits

Background and Assumptions

Knowledge is a critical determinant of economic growth and standard of living. A strong consensus, reflected in recent policy statements from the OECD, the World Bank, and others, is emerging: *knowledge is the most important factor in economic development*. The OECD concluded that "underlying long-term growth rates in OECD economies depend on maintaining and expanding the knowledge base."[4] The World Bank's 1998/99 World Development Report states that "Today's most technologically advanced economies are truly knowledge-based...creating millions of knowledge-related jobs in an array of disciplines that have emerged overnight," and "the need for developing countries to increase their capacity to use knowledge cannot be overstated." Improving this capacity is becoming a pre-requisite for sustained economic growth and improved quality of life. World Bank senior management is committed to working with clients who are developing strategies to narrow knowledge gaps with the advanced countries [see 10/15/98 minutes of "Meeting with Mr. Wolfensohn to Discuss Millennium Institute/Centers of Excellence concept"].

Knowledge is transformed into goods and services through a country's National Innovation System. Knowledge by itself does not transform economies. Its benefits appear when it is employed within a complex system of institutions and practices known as a National Innovation System (NIS). An NIS is a web of: (i) knowledge producing organizations in the education and training system (such as universities and research institutes); (ii) the macroeconomic and regulatory framework, including trade policies that affect technology diffusion; (iii) communications infrastructures; and (iv) selected other factors, such as access to the global knowledge base or certain market conditions that favor innovations. A NIS is effective to the extent that these elements are developed and work in harmony.

Cutting-edge research is an essential part of an effective NIS. New knowledge drives innovation. In most cases,[5] there are several reasons why at least some of a country's researchers should be at the forefront of their disciplines. First, even in cases where innovation policy is primarily concerned with adaptation rather than production of knowledge, the intellectual rigor required usually results from "pursuing the leader" at the forefront of discipline. Second, since so much of scientific knowledge creation involves the "free exchange" of ideas among colleagues worldwide [all of whom are seeking recognition and prestige], countries integrate best and benefit most when they have knowledge to offer. For countries of a basic level of scientific development, it is possible to be an absolute follower and taker from the world's knowledge base—but such a strategy is neither efficient nor sustainable. In the long-term, countries that wish to use knowledge must also get involved in its production. Third, university-based research—relatively small compared with other university activities—has a disproportionately large effect that energizes both educational and innovation systems.

---

[4] OECD 1998, "Technology, Productivity, and Job Creation: Best Policy Practices." P.4.

[5] Depending on stage of development. Among the most impoverished countries, there a certainly more pressing priorities than developing research excellence. Other countries must decide very selectively how they will spend their limited resources on national knowledge strategies. These countries may be too poor to be effective participants in the global knowledge system. Above a certain level of economic development [that typically found in most Latin American countries, for instance], it becomes essential to take part in global knowledge production and use.

Science and technology are intertwined. There is still much truth in the common view that the most important technological breakthroughs occurred because scientists were investigating nature—not because they were looking for applications of their research [e.g., Faraday's and Maxwell's work was pure science, but it facilitated Marconi's and others' work on wireless communication]. However, because it is increasingly true that new technologies give rise to new sciences and disciplines [e.g., chemical engineering], it is most accurate to view science and technology as intertwined. According to Richard Nelson,[6] this intertwining is the principal reason why technology is advanced through the work of men and women who have university training in science and engineering. It is also "the principal reason why, in many fields, university research is an important contributor to technological advance, and universities as well as corporate labs are essential parts of the innovation system. Thus the problems that originate in industry are not explored only by industrial scientists. They feed into, and stimulate, the entire scientific community."

Trained human brains are the most effective knowledge transfer and adaptation mechanism. Innovation is not a linear process of "science push" leading to applications. The idiosyncratic nature of scientific and technological advance is best promoted by individuals who are comprehensively trained in their disciplines. Proper incentive systems are necessary, and discrete actions such as tech transfer via trade in goods also contribute. But, in the long run, the expertise gained through training is the decisive factor in the economic impact of technology transfer.

Good science is international. Nature does not respect political boundaries. In response, science has evolved as an international endeavor. Those who work at the forefront of their disciplines seek to interact and collaborate with their peers regardless of where they are. Conversely, researchers need access to global interchange of knowledge to avoid obsolescence and insularity.

Anonymous peer review and competitive funding facilitate quality and productivity in science and technology. Allocation practices that rely on anonymous review by qualified scientific peers and open, transparent, merit-based competition for resources are nearly universally acknowledged as the most effective means of distributing research resources. In such systems, scientific recognition is the foundation upon which careers are built, and access to resources is the means to recognition. This creates strong incentives for researchers to maximize their productivity, by adding graduate students and spending their budgets wisely. As a result, in such systems *the most- highly selected researchers tend to be the most efficient and productive.*

The Millennium Science Initiative

In its most basic form, the MSI is a competitive fund for research support with a light administrative structure. It is expected that several client countries would seek to promote research excellence under the MSI. While the MSI would be adapted to the particular needs of the individual client countries that participate, the initiative would share some basic common characteristics anywhere it is implemented.

Support for top-quality science through a competitive fund. Many developing countries get low returns from their R&D investments because, inter alia, they do not follow best practice in selection, allocation, and implementation procedures [see paragraph 7 above]. The Millennium Science Initiative seeks to test the extent to which higher returns can be induced through the introduction of state-of-the-art selection and funding criteria.

Involvement of the international community in the selection process. All MSI-funded activities will be vetted through selection processes that involve world-class international peers. Where appropriate, some high qualified scientists would provide general direction and oversight, and help facilitate networking and exchange.

---

[6] R.Nelson, National Innovation Systems: A Comparative Analysis, New York: Oxford University Press, 1993. P.7.

Increased training opportunities. In countries where the MSI would operate, there is typically found a dearth of quality graduate training opportunities for bright young minds; training systems often lack quality and dynamism, taking a long time to produce a few graduates. All research funded through the MSI be directly connected to increase provision of training opportunities for graduate students. In connection with their research—and as a requirement for selection--investigators will be expected to train and advise the maximum feasible number of graduate students.

Global and regional connections to other researchers. The Report of the International Advisory Group on Science and Technology emphasized the need to overcome isolation, with institutes that are connected "to the private sector, to colleges and secondary schools, to the institutions in which they are housed, and to other centers and universities" ["Realizing the Globalization of Discovery" p.9]. The selection process itself would help disseminate the activities of the MSI host countries abroad. The research projects would similarly provide opportunities for international collaborations through long-term and visiting professorships, post-doctoral and doctoral positions. In addition, each funded group would cooperate with the overall Program Committee on a series of targeted activities which integrate with national and international partners.

Expected Benefits

Aside from increased training opportunities and integration with the international scientific community, the MSI initiative is expected toward contribute to three other main benefits:

Stem "brain drain". In the U.S., arguably the world's most scientifically advanced country, 20% of university science and engineering faculty are foreign born, and this percentage is rising. Brain drain is not new, but it is predictable: the most talented individuals would get their education and pursue their careers wherever they find the best opportunities to do quality work and secure funding. Because geographic isolation is still extremely detrimental to research careers, the best would not stay in their countries unless a critical mass of quality researchers appears. The MSI would contribute toward creating this by providing career opportunity to the most qualified national researchers and by attracting top-quality international talent.

Forging cultures of quality. In underperforming research systems, it is common to find an aversion to the difficult choices necessitated by true competition for resources. Typically, anyone with reasonable scientific credentials can "survive", when survival means bad infrastructure, obsolete equipment, and inadequate professional autonomy. By contrast, advanced scientific countries will usually have flagship funding agencies in which only the top researchers get considered for funding, but those who are funded are given the resources and freedom to do their best work. As countries attempt to transition from one system toward the other, researchers must become accustom to abiding by decisions [of qualified peers] that nourish the best and starve the inadequate among them. Resistance to this change is common, but perseverance for a sustained period (10 years or more) typically results in research community that is healthier and much more dynamic.

Pressure for transparency and merit-based allocation procedures. This is a corollary to the social learning process that leads to a culture of quality described in paragraph 13. The introduction of allocation procedures that favor the most qualified tends to create a vocal group that seek to maintain fair, open processes. This group wants the opportunity to compete and be rewarded according to their objectively-evaluated merits. The sense of resignation to an unfair status quo can be overcome through this type targeted intervention.

Annex 4
Millennium Science Initiative Project
Estimated Project Costs

Project Component	Local	Foreign	Total
	US $ million		
1. Management Structure for the Millennium Science Initiative	**0.5000**	**0.5000**	**1.0000**
a) Board of Directors	0.0125	0.0125	0.0250
b) Program Committee	0.0500	0.0500	0.1000
c) Peer Reviewers	0.0150	0.0150	0.0300
d) Implementation and Management Support Unit	0.3350	0.3350	0.6700
e) Studies: scale-up, M&E, surveys, baseline and tracer studies	0.0875	0.0875	0.1750
2. Competitive Fund for Scientific Excellence	**8.5250**	**3.4750**	**12.0000**
a) Science Institutes	6.4000	2.6000	9.0000
b) Science Nuclei	2.1250	0.8750	3.0000
3. Network for the promotion of Scientific Excellence	**0.7500**	**0.7500**	**1.5000**
a) Visits to establish the network	0.0250	0.0250	0.0500
b) Exchange programs for researchers, post-docs, and graduate students	0.5500	0.5500	1.1000
c) International advanced courses	0.1500	0.1500	0.3000
d) Dissemination of lessons learnt	0.0250	0.0250	0.0500
Total Baseline Cost	**9.7750**	**4.7250**	**14.5000**
Physical Contingencies	**0.1500**	**0.1500**	**0.3000**
Price Contingencies	**0.0750**	**0.0750**	**0.1500**
Front End Fee	**0.0000**	**0.0500**	**0.0500**
Total Project Cost	**10.0000**	**5.0000**	**15.0000**

Annex 5

Economic Analysis and Related Issues

Background: Social Rates of Return to Innovations and R&D. A number of studies (Mansfield, 1977; Griliches and Lichtenburg, 1984; Bernstein and Nadiri, 1998) have concluded that the social rates of return to innovations and to R&D in developed countries are high (on average over 20%, and for some industries above 70%). Commercially viable innovations tend to lower the cost of production, leading to lower prices (consumer surplus) and/or resource savings which increase output elsewhere in the economy. In addition, close links have been established between academic research and the development of new products and processes (Nelson, 1986; Jaffe, 1989; Mansfield, 1991). In several industries, a substantial proportion of new products and processes (10%-20%) could not have been developed (or, not without substantial delay) in absence of academic research that had been carried out within the previous two decades. Further work by Francis Narin in 1997 found that 73% of papers cited in US industry patents were from publicly-funded research conducted either at universities or public research institutions.

Perhaps most relevant to this project, Mansfield (1993) found that most important contributions to industrial innovation came from university research done at the departments that were **world-leaders** in their domain. This same study found **geographical proximity** of university-based research to be another important factor contributing to industrial innovations. Among the study's findings were that, "there are many advantages to firms working with, and keeping abreast of, developments at local universities." Furthermore, **students were found to play an important role as transfer agents:** studies of the US NSF's Industry/University Cooperative Research Program found better personnel recruitment to be one of the principal benefits of their participation in the program. Both Mansfield (1993) and Peters and Fusfeld (1982) found students to be a strong transfer mechanism in innovation: citations in patent applications of the work of former mentors by students who had taken jobs in private research labs were well above the general average of citations.

These findings argue very strongly for investments in improving the quality of the best researchers in Chile's universities, and of prioritizing human resources training for the sake of technology transfer. However, some important caveats must be considered: (a) the results of academic research are utilized in many places, and appear in the economic sphere two or three steps removed from where they were created (with an average time interval of seven years, which may extend up to two decades in some cases); (b) industries in developing countries may lack private R&D facilities, may produce very few innovations (concentrating on adaptations instead), may have weak design capacity, and low or negligent private investment in R&D, and ; (c) the economic context in developing countries may be characterized by distorted prices and markets, lack of competition, and irrational or short-sighted legal and regulatory frameworks.

Even without these conditions, precise measurement of the returns to R&D is hampered by at least two important conceptual constraints: (a) the long time between the conduct of research and the appearance of results, and (b) the difficulty in valuation of factors such as the contributions of strong basic science education in K-12 and at the undergraduate level, or mature communications information and communications infrastructures.

For these reasons, and consistent with the LIL guidelines, no full-scale formal cost-benefit analysis was conducted during preparation. Under the project itself (and under the follow-on activities), information will be collected and analysis will be performed principally on efficiency and productivity gains in research and improvements to the stock of highly-trained human capital. This will be in preparation for an eventual formal cost-benefit analysis, in the appropriate time frame.

The Short Term Goal: Measuring Cost-effectiveness and Private Returns to Researchers. The Program Committee and the Implementation and Management Unit (PC and IMU) would conduct or oversee the collection of data on the efficiency and productivity of MSI-funded researchers and research. This would be compared with baseline data for the sector as a whole. A value would be computed for both the direct saving under the MSI, and for any other saving induced by the MSI's influence on the rest of the

Chilean system. Efficiency savings are expected to come from: (i) focusing resources on the best researchers—those of proven merit and record of past performance--as identified through the high-level selection process; (ii) introducing a "light model of administration" which decreases the bureaucratic burden on investigators; and (iii) providing sufficient resources to allow investigators to staff their labs and purchase the necessary equipment needed to work on the most relevant, cutting edge research problems.

Private returns to those trained in connection with MSI-funded research would give an important initial indication of the potential market value of increased investment and improved quality of research. Again, time horizons are long, but detailed data will be collected on: (i) collaborations (especially if they are remunerative) by MSI researchers with private firms; (ii) job offers, salaries, nature of (public or private) and time-to-first employment for all graduate students and post-doctoral fellows connect to the MSI (as well as for grad students and post-docs in Chile as a whole); and (iii) increases in training opportunities, and changes in the profile (especially the quality) of students selecting careers in research. Clearly, several independent variables other than the project will influence these factors. Nonetheless, carefully conducted analysis should yield insight on whether the MSI is providing human resources training that is valuable in the labor market and the economy. Because of the present dearth of Ph.D.s, the private return to those trained under the project will be monitored versus that of those trained abroad, to gauge the perceived value of the training. Likewise, the returns will be tracked over time to see if they diminish as the project adds additional highly-trained individuals.

The Long-term Goal: Measuring the Specific Impact on the Chilean Economy. Over the very long term (ten years or more) the goal is to measure the direct effect of the activities and outputs of the project on the Chilean economy. Increased productivity and output in the economy may result from greater success in commercialization of fundamental and applied research. This is likely to result from: (a) increased absolute numbers of researchers working in private firms; (b) better skills of S&T researchers (both in firms and the public sector); and (c) a greater focus of R&D on economically relevant areas. The impact in the economy could appear as greater output from existing firms, the creation of new, technologically-oriented firms, a shift toward higher quality products, and/or improved socioeconomic performance, (improvements in health, environments, etc.).

Once again, one should not expect drastic changes in the economy because: (i) the investment is very small compared to the size of the economy; (ii) the project encourages private sector cooperation, but does not mandate it; (iii) the purported economic relevance of the research is only one criterion for selection; and (iv) several independent variables (e.g., worsening regional macroeconomic conditions) could mitigate or nullify the positive impact of the project.

Annex 6
Millennium Science Initiative Project
Procurement and Disbursement Arrangements

General. Goods and works shall be procured in accordance with the provisions of the "Guidelines for Procurement under IBRD Loans and IDA Credits" (The Guidelines), published by the Bank in January 1995 and revised in January and August 1996, and September 1997.

A. Competitive Fund for Science Excellence (Fund to support Millennium Science Institutes and Science Nuclei) (The Fund)

The Fund will award grants for research, human resource formation and outreach activities. The total amount of grants is estimated at US$ 12.0 million. Principal Investigators (PI) at universities and non-university centers will apply for these grants. Applications will include a program of activities and a general services and technical assistance through **individual consultants or single source selection** whenever only one individual or firm is qualified or has experience of exceptional worth for the assignment [Clause 5.1 (c) and 3.9 (d) of the Guidelines]. Other contracting of consultants will follow Consultant's Qualifications or Quality- and Cost-based selection procedures

B. Other Components.

Any procurement of goods and contracting of consultants for the other components of the project will be carried out according to the Bank Guidelines and the procedures outlined below. The aggregated amounts indicated below **do not include** amounts assigned to the Fund.

Civil Works: The Project does not foresee any procurement of civil works with Bank financing other than those contemplated by the Institutes and Nuclei for carrying out rehabilitation / construction of research facilities.

Goods: Goods estimated to cost up to US$100,000 shall be procured using National Shopping procedures up to an aggregate amount of US$150,000.

Consultant Services: Consultant's services shall be procured in accordance with the provisions of the "Guidelines: Selection and Employment of Consultants by World Bank Borrowers" published by the Bank in January 1997, revised in September 1997, and the provisions in the Loan Agreement

Firms regardless of the contract cost, may be contracted under Quality-and-Cost-Based Selection (QCBS) procedures, except as indicated below. Other services to be contracted by the IMU, such as surveys, background studies, study-tours, technical assistance, audits, estimated to cost less than US$200,000 may be selected based on Consultants' Qualifications procedures. Specific services and technical assistance will be contracted through **individual consultants or single source selection** whenever only one individual or firm is qualified or has experience of exceptional worth for the assignment [Clause 5.1 (c) and 3.9 (d) of the Guidelines].

Bank Review (prior and post)

In accordance with the institutional learning expectations for this LIL, and to minimize process delays, prior reviews by the Bank will be carried out for only the first two of select types of procurement procedures. Thereafter, and at the end of each trimester, Institutes and Nuclei will submit to the IMU a report of expenditures and the Bank supervision missions will carry out a *ex-ante* assessments of the procurement processes described above. Biannual procurement audits will be carried out by independent auditors and submitted to the Bank during the three months following the audit to assure the required controls. The PIs and the IMU should keep records of all procurement actions they carry out to allow the Bank to carry out its post-reviews and audits; they should also submit to the Bank every six months a list of all contracts signed indicating the name of the contracted firm, the amount and the objective of the contract.

Bank Prior review would be required for the following procurement actions for Consulting Services: (a) all consultants' services provided by a firm, estimated to cost US$100,000 or more; all consultants' services provided by an individual estimated to cost US$75,000 or more and (b) any amendment of contracts resulting in the increase of the contract value beyond the review limits set in (a) and (b) above.

A **Procurement Plan,** satisfactory to the Bank, for the first six months of implementation of the project (not including the Fund) should be submitted by June 30, 1999. Thereafter, biannual procurement plans will be submitted. The IMU shall create the procurement plan by consolidating the plans from the SIs and SN. The plan shall specify the aggregate amounts for each type of expenditure (equipment, reagents, fellowships, etc.) and procurement procedures (direct contracting, local shopping, national competitive bidding, etc.) used for acquisition of good and services during a given six-month period. Standard Documents for national procurement and contracting of consultants will be developed by the IMU for the use of PIs (grant recipients) and approved by the Bank before the first request for proposals. Participating Institutes and Nuclei will follow procurement procedures detailed in a Procurement Manual, satisfactory to the Bank, and to be completed before awarding the first grant. The Manual also details reporting and auditing requirements to ensure proper coordination with the IMU and use of resources. In cases where justification may be required, the IMU will liaise with the SI or SN to assure compliance with procedures. In general, the IMU will oversee procurement and notify the Bank of any situations warranting attention. A project launch workshop will be organized at an early stage in Project Implementation to familiarize the implementing unit and other institutions involved in the execution of projects. The workshop will cover procurement, disbursement, reporting and auditing requirements. The General Procurement Notice is planned to be published by April 30, 1999.

Annex 6, Table A: Project Costs by Procurement Arrangements \a
(In US$ million equivalent)

Expenditure Category	**Procurement Method** NCB	Other	N.B.F	**Total Cost (including contingencies)**
A1. Competitive Fund for Science Excellence (goods and services)		**12.000** **(3.475) c/**		**12.000** **(3.475)**
B. Other Components				
2. Goods				
Communication and Computer Equipment, Publications		**0.150 a/** **(0.075)**		**0.150 a** **(0.075)**
3. Services				
Consultants, Technical Assistance, Training, Studies		**2.300** **(1.150) b/**		**2.300** **(1.150)**
4. IMU Operating Expenses		**0.500** **(0.250) a/**		**0.500** **(0.250)**
5. Front-end Fee		**0.050** **(0.050)**		**0.050** **(0.050)**
Total		**15.000** **(5.000)**		**15.000** **(5.000)**

Note: N.B.F. = Not Bank-financed
Figures in parenthesis are the amounts to be financed by the Bank loan.

a. National shopping
b. Consultant's guidelines.
c. As stipulated in the Loan Agreement and required by each research program.

Annex 6, Table B: Thresholds for Procurement Methods and Prior Review
(In US$'000)

Expenditure Category	Contract Value (Threshold)	Procurement Method	Contracts Subject to Prior Review
COMPETITIVE FUND FOR SCIENCE EXCELLENCE			
(a) Works	>350-5,000 <350	NCB Three Quotations	First two First two
(b) Goods -Scientific Equipment -All other goods in PI's Proposals	Regardless of Value Regardless of Value	Direct contracting Direct contracting, Shopping (International / National)	First two First two
(c) Services \a - Firms - Individuals	Regardless of Value Regardless of Value	Single Source Selection Consultants' Qualifications Individuals Consultants	All over 100 All over 100 All over 75
OTHER COMPONENTS \b			
(a) Goods Communication and Computer Equipment Publications	<100	National Shopping	First two
(b) Services - Firms - Individuals	>200 <200 Regardless of Value Regardless of Value	QCBS Consultants Qualifications Single Source Selection Individual Consultants	All All over 100 All over 100 All over 75

a. There are not contracts expected to cost over $100,000 with firms or over $75,000 with individuals within the Grants.
b. No Civil Works are foreseen other than those contemplated under the Fund programs.

Annex 6, Table C: Allocation of Loan Proceeds

Expenditure Category	Amount in US$ million	Disbursement Percentage
Fund for Scientific Excellence	3.475	50% of amount of each grant agreement
Goods: Communication and Computer Equipment and Publications	0.075	50%
Services: Consultants, Technical Assistance, Studies, Training	1.150	50%
IMU Operating Expenditures[7]	0.250	50%
Front End Fee	0.050	100%
Total	**5.000**	**33%**

Disbursement

Allocation of Credit Proceeds. The Project is expected to be completed over a two year period with a closing date of March 31, 2002. IBRD funds will be disbursed according to the categories and percentages shown in Table C of this Annex. Government's counterpart funds needed for each fiscal year to cover the share of total project expenses not financed by IBRD will be allocated in each year's budget made available for the project.

Use of Statements of Expenditures. Disbursements of the loan proceeds for research grants, and for contracts valued at less than USD 200,000 for goods and works, and less than USD 100,000 for consulting firms (USD 75,000 for individual consultants), local training , and operating costs will be made against Statements of Expenditures (SOEs). The documentation supporting claims under SOEs will be retained by Science Institutes, Nuclei and the IMU and made available for review and examination by auditors and Bank supervision mission members.

Special Account. To facilitate disbursements and timely project implementation, the Government will open, maintain and operate a Special Account in US dollars, under terms and conditions satisfactory to the Bank, to cover the Bank's share of eligible expenditures. Disbursements out of the Special Account will be made against grant agreements twice a year for each grant agreement. The Authorized Allocation and initial deposit to the Special Account will be US$ 500,000.00. Further replenishments will be made on the basis of applications documenting the amounts actually expended from the Special Account.

[7] "Operating Expenditures of the Project Unit" means the cost of remuneration of IMU and Program Committee personnel, secretarial services, office leasing, utilities, office supplies and materials.

Annex 7, Millennium Science Initiative Project
Project Processing Budget and Schedule

Project Schedule	**Planned** (At final PAD stage)	**Actual**
Time taken to prepare the project (months)		
First Bank mission (identification)	11/13/1998	11/13/1998
Appraisal mission departure	01/25/1999	01/25/1999
Negotiations	01/28/1999	03/17/1999
Planned Date of Effectiveness	04/01/1999	06/01/1999

Prepared by: Science Advisory Committee Office of the President/ Ministry of Planning

Bank staff who worked on the project included:

Name	Specialty
Lauritz Holm-Nielsen	Task Team Leader
Cesar Yammal	Consultant
Michael Crawford	Science and Technology Specialist
Marta Molares-Halberg	Legal Counsel
Esther Peckham	Task Assistant
Marian Kaminskis	Task Assistant
Ruth Izquirdo	Task Assistant
Aron Kupperman	Consultant
Max Brennan	Consultant
Tom Hexner	Consultant
Marta Ospina	Procurement
Jaime Román	Procurement
Efraím Jiménez	Procurement
Susana Cirigliano	Financial Management Specialist
Livio Pino	Financial Management Specialist
Paul Vandenheede	Disbursement Officer
William Saint	Peer Reviewer
Carl Dahlman	Peer Reviewer

Annex 8
Millennium Science Initiative Project
Documents in the Project File*

A. Millennium Science Initiative –General Bibliography

1. Realizing the Globalization of Discovery. Report of the International Advisory Group on Science and Technology. June 4-5, 1998.
2. Chile: Centers of Excellence, Technical Assistance Mission, September 21-25, 1998. Aide Memoire.*
3. Memorandum from Mr. Robert T. Watson to Mr. James Wolfensohn briefing the status of the Millennium Institutes Project. October 15, 1998.*
4. Minutes of Meeting with Messrs. J. Wolfensohn, Shahid Javed Burki, Robert T. Watson, Lauritz Holm-Nielsen, Phillip Griffith (Institute for Advanced Studies at Princeton) on October 15, 1998.*
5. Initiative Design Summary.
6. Centers of Excellence in Science and Technology - Work Program and Budget Proposal., October 1998*.

B. Chile Millennium Science Initiative – Related Documents

7. Programa Nacional de Cooperación Técnica entre el Gobierno de Chile y el Programa de las Naciones Unidas para el Desarrollo, 1987 – 1991: Un Análisis del Primer Bienio. Enero de 1989.
8. *Fundación Chile*. Annual Report 1997.
9. Manual de Gestion de la Cooperacion Internacional, Proyecto CHI/87/034, CINDA/PNUD
10. Manual Regulacion Juridica de la Actividad Cientifica y Tecnologica, Proyecto CHI/92/007, CINDA/PNUD
11. Estado, Mercado y Conocimiento: Politicas y Resultados en la Educacion Superior Chilena 1960-1990, Jose Joaquin Brunner, Hernan Courard, Cristian Cox.
12. Cuanto vale Estudiar un Postgrado en America Latina? Augusto Franco Arbelaez, IDRC.
13. Desafios de la Educacion Superior (Seminario Internacional sobre Educacion Superior), Unidad de Analisis de Polticas Sociales (UDAPSO), La Paz, 1993.
14. Project Appraisal Document – Chile Higher Education Improvement Project, October 19, 1998.
15. *Mansfield, Edwin,* "Economic Returns From Investments in Research and Training," HRO Working Paper HROWP 19, World Bank, Washington, D.C., 1994.
16. Committee on Science, Engineering, and Public Policy, "Capitalizing on Investments in Science and Technology" National Academy Press, Washington, D.C. 1999.
17. Popper et al., "New Forces at Work; Industry Views Critical Technologies," Rand/Critical Technologies Institute, Washington, D.C. 1998.
18. Goscinski, Osvaldo, et al. Evaluation of IDB's Science and Technology Programs in Chile, Costa Rica, and Uruguay Final Report. Inter-American Development Bank, 1998.
19. *Conicyt*. Proposiciones para el Desarrollo Cientifico-Tecnologico de Chile. Consejo Asesor de Conicyt
20. *Conicyt*. Analysis and Projections of Chilean Science. Academia Chilena de Ciencias

C. Centers of Excellence and Science and Technology – Background Papers

21 Science and Technology Program Evaluation – Synthesis Report. Inter-American Development Bank, Evaluation Office. January 1998.

22. Memorandum to Mr. Ismail Serageldin, Vice-President ESD, from Michel Petit, Director ESDAR on Back to office report of Foundation Meeting of the Commission on Science and Technology for Sustainable Development in the South (COMSATS), Islamabad, October 4-5, 1994.

23. *Mervis, Jeffrey D. and Dennis Normile.* Article of Science magazine "Science in Southeast Asia." March 1998.

24. Article of Nature magazine "South American science at a crossroads." April 16, 1998, Volume 392, Issue No. 6677.

25 *Reinach, Fernando C.* Article of Nature magazine "Adapting to change in Latin America."

26 *McMahon, Matthew.* Getting Beyond the "National Institute Model" for Agricultural Research in Latin America – A Cross-Country Study for Brazil, Chile, Colombia and Mexico. August 1992.

27 Science and Technology Program Evaluation – Project Performance Review. Brazil: Science and Technology Program Loan 620/OC-BR. *Inter-American Development Bank, Evaluation Office.*

28. Propuesta de Préstamo: Argentina - Programa de Modernización Tecnológica. Inter-American *Development Bank..*

29. *Korea Science and Engineering Foundation.* Centers of Excellence (SRC, ERC).

30. *Roessner, J. David, Alan L. Porter & Huaidong Xu.* National Capacities to Absorb and Institutionalize External Science and Technology. Technology Analysis & Strategic Management, Vol. 4, No. 2, 1992.

31. *Birdsall, Nancy and Changyong Rhee.* Does Research and Development Contribute to Economic Growth in Developing Countries? Policy Research Working Paper 1221.

32. *Mayorga, Román.* Cerrando la brecha. Inter-American Development Bank, 1996.

33. *Levy, Daniel C.* Building the Third Sector. Latin America's Private Research Centers and Nonprofit Development, Pittsburgh, 1996

34. *Cardoza, Guillermo.* Higher Education, Scientific Research and Sustainable Development in Latin America: Elements for a New Agenda. Harvard International Institute for Development, 1996.

35. *Macilwain, Colin.* World Bank backs Third World Centres of Excellence Plan. Nature, 1998.

36. *Subbarao, K., Raney, Laura,Dundar Halil, Haworth, Jennifer.* Women in Higher Education. World Bank, Discussion Papers 244.

37. Engineers for the 21st Century, Royal Swedish Academy of Engineering Sciences

38. Les Sciences hors d'Occident au Xxeme Siecle, 19-23 Septembre 1994, Orstrom, Paris.

39. Cooperation in Science and Technology – An Evaluation of the U.S. Soviet Agreement, Catherine P. Ailes and Arthur E. Pardee, Jr.

40. Women and Minorities in Science and Engineering,, National Science Foundation, January 1990

41. El Mercado de Valores – Desarrollo Industrial y Cambio Tecnologico, Nacional Financiera, Febrero de 1999

42. Science and Engineering Indicators 1998, National Science Foundation

43. Project Appraisal Document, Brazil Science and Technology Reform Support Project, November 26, 1997.

44. The World Bank Discussion Papers #325, Institutional and Entrepreneurial Leadership in the Brazilian Science and Technology Sector, edited by Lauritz Holm-Nielsen, Michael Crawford and Alcyone Saliba.

*Including electronic files.

Annex 9
Millennium Science Initiative Project
Statement of Loans and Credits

Status of Bank Group Operations in Chile
Operations Portfolio

Project ID	Fiscal Year	Borrower	Purpose	Original Amount in US$ Millions				Difference Between expected and actual disbursements a/		Last PSR Supervision Rating b/	
				IBRD	IDA	Cancel.	Undisb.	Orig	Frm Rev'd	Dev Obj	Imp Prog
Number of Closed Projects: 52											
Active Projects											
CL-PE-6664	1993	REPUBLIC OF CHILE	ENVIRON/INSTIT DEV	11.50	0.00	0.00	1.07	1.06	0.00	S	S
CL-PE-6639	1993	REPUBLIC OF CHILE	HEALTH SECTOR	90.00	0.00	0.00	14.80	14.80	14.80	S	S
CL-PE-6612	1993	MINISTRY OF FINANCE	IRRIG DEV	45.00	0.00	31.00	3.36	32.36	1.02	S	S
CL-PE-6673	1995	REPUBLIC OF CHILE	SECONDARY ED	35.00	0.00	0.00	25.35	16.11	0.00	HS	HS
CL-PE-6661	1995	MIN PUB WORKS (MOP)	THIRD RD SCTR	120.00	0.00	0.00	64.48	55.12	0.00	S	S
CL-PE-6676	1996	GOVT OF CHILE	SECANO AG DEV I	15.00	0.00	0.00	7.28	3.66	0.00	S	S
CL-PE-55481	1999	GOVERNMENT	HIGHER EDUCATION	145.45	0.00	0.00	145.45	0.00	0.00		
Total				461.95	0.00	31.00	261.79	123.11	15.82		

	Active Projects	Closed Projects	Total
Total Disbursed (IBRD and IDA):	169.16	2,784.98	2,954.14
of which has been repaid:	4.50	1,958.77	1,963.27
Total now held by IBRD and IDA:	426.45	831.37	1,257.82
Amount sold	0.00	7.19	7.19
Of which repaid	0.00	7.19	7.19
Total Undisbursed	261.79	5.16	266.95

a. Intended disbursements to date minus actual disbursements to date as projected at appraisal.

b. Following the FY94 Annual Review of Portfolio performance (ARPP), a letter based system was introduced (HS = highly Satisfactory, S = satisfactory, U = unsatisfactory, HU = highly unsatisfactory): see proposed Improvements in Project and Portfolio Performance Rating Methodology (SecM94-901), August 23, 1994.

Note:

Disbursement data is updated at the end of the first week of the month.

Chile
STATEMENT OF IFC's
Committed and Disbursed Portfolio
As of 31-Oct-98
(In US Dollar Millions)

		Committed				**Disbursed**			
		IFC				**IFC**			
FY Approval	**Company**	**Loan**	**Equity**	**Quasi**	**Partic**	**Loan**	**Equity**	**Quasi**	**Partic**
1987/88/89	Celulosa Arauco	0.00	0.00	7.50	0.00	0.00	0.00	7.50	0.00
1989/91	Escondida	11.18	7.48	0.00	1.36	11.18	7.48	0.00	1.36
1989/93/94	CELPAC	9.12	0.00	0.00	5.00	9.12	0.00	0.00	5.00
1990	ING-MLF-Nature F	1.20	0.00	0.00	1.80	1.20	0.00	0.00	1.80
1990/92/93	CTC	14.76	0.00	20.00	16.19	14.76	0.00	20.00	16.19
1990/94	Leasing Andino	8.75	0.00	0.00	12.50	8.75	0.00	0.00	12.50
1991/93	Aconcagua	0.00	6.45	0.00	0.00	0.00	6.45	0.00	0.00
1991/93	FIBRANOVA	0.00	1.54	2.00	0.00	0.00	1.54	2.00	0.00
1991/94	BOMASA	1.89	2.00	2.80	2.06	1.89	2.00	2.80	2.06
1993	Pangue	0.00	4.70	0.00	0.00	0.00	2.82	0.00	0.00
1994	Pionero Fondo	0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00
1994/96/97	Moneda Asset Mgt	0.00	.46	0.00	0.00	0.00	.46	0.00	0.00
1995	Latasa-Chile	4.50	2.50	0.00	0.00	4.50	2.50	0.00	0.00
1996	FEPASA	14.50	0.00	6.00	6.00	13.44	0.00	6.00	5.56
1996	Proa Fund	0.00	8.40	0.00	0.00	0.00	8.32	0.00	0.00
1997	Agrisouth Chile	10.00	0.00	0.00	5.00	10.00	0.00	0.00	5.00
	Total Portfolio:	75.90	43.53	38.30	49.91	74.84	41.57	38.30	49.47

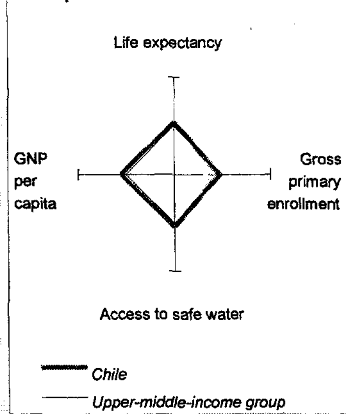
		Approvals Pending Commitment			
		Loan	**Equit**	**Quasi**	**Partic**
1999	CBT	0.00	8.00	0.00	0.00
1999	CBTI	0.00	0.00	2.00	0.00
1999	ESCONDIDA RI	0.00	0.00	25.00	0.00
1994	MERSAN	0.00	0.00	3.00	0.00
	Total Pending Commitment:	0.00	8.00	30.00	0.00

Annex 10
Chile at a Glance

9/28/98

POVERTY and SOCIAL	Chile	Latin America & Carib.	Upper-middle-income
1997			
Population, mid-year *(millions)*	14.6	494	571
GNP per capita *(Atlas method, US$)*	5,020	3,880	4,520
GNP *(Atlas method, US$ billions)*	73.4	1,917	2,584
Average annual growth, 1991-97			
Population *(%)*	1.5	1.7	1.5
Labor force *(%)*	2.1	2.3	1.9
Most recent estimate (latest year available, 1991-97)			
Poverty *(% of population below national poverty line)*	21	..	..
Urban population *(% of total population)*	84	74	73
Life expectancy at birth *(years)*	75	70	70
Infant mortality *(per 1,000 live births)*	11	32	30
Child malnutrition *(% of children under 5)*	1	..	..
Access to safe water *(% of population)*	85	73	79
Illiteracy *(% of population age 15+)*	5	13	15
Gross primary enrollment *(% of school-age population)*	100	111	107
Male	..	..	..
Female	..	..	..

Development diamond*

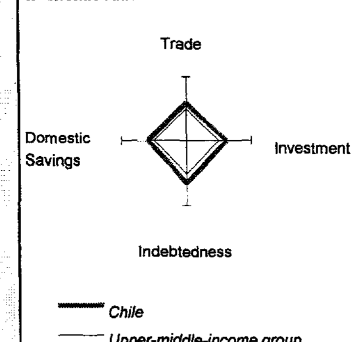


KEY ECONOMIC RATIOS and LONG-TERM TRENDS

	1976	1986	1996	1997
GDP *(US$ billions)*	9.9	17.7	68.6	75.9
Gross domestic investment/GDP	15.7	18.9	26.6	26.9
Exports of goods and services/GDP	25.1	29.1	28.2	26.9
Gross domestic savings/GDP	20.0	21.9	24.5	24.5
Gross national savings/GDP	..	11.5	20.8	21.4
Current account balance/GDP	..	..	-5.5	-5.3
Interest payments/GDP	2.6	7.9	1.7	1.4
Total debt/GDP	57.0	119.4	40.0	41.4
Total debt service/exports	..	..	32.7	20.9
Present value of debt/GDP	57.0	119.4	44.0	..
Present value of debt/exports	..	..	160.8	..

	1976-86	1987-97	1996	1997	1998-02
(average annual growth)					
GDP	3.2	8.0	7.4	7.1	4.5
GNP per capita	-0.3	6.4	6.0	5.8	3.4
Exports of goods and services	5.8	10.6	10.0	9.9	7.5

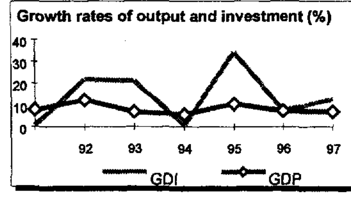
Economic ratios*



STRUCTURE of the ECONOMY

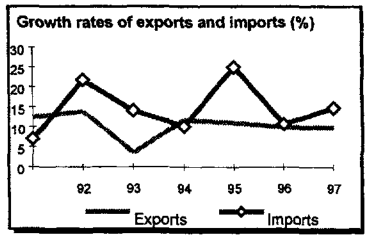
	1976	1986	1996	1997
(% of GDP)				
Agriculture	8.5	9.0	7.1	8.4
Industry	40.5	37.0	39.3	35.1
Manufacturing	23.6	18.7	20.6	17.2
Services	51.0	54.0	53.6	56.5
Private consumption	66.0	65.5	65.3	65.5
General government consumption	14.0	12.6	10.2	10.0
Imports of goods and services	20.8	26.0	30.3	29.2

Growth rates of output and investment (%)



	1976-86	1987-97	1996	1997
(average annual growth)				
Agriculture	2.9	6.4	3.9	-0.2
Industry	3.0	6.8	6.5	6.2
Manufacturing	1.7	6.4	3.5	4.4
Services	2.8	7.7	7.5	7.6
Private consumption	2.1	8.6	8.8	8.4
General government consumption	0.1	3.5	3.1	3.3
Gross domestic investment	4.5	13.7	7.5	12.8
Imports of goods and services	1.9	14.4	10.7	14.8
Gross national product	1.3	8.2	7.5	7.2

Growth rates of exports and imports (%)



Note: 1997 data are preliminary estimates.

* The diamonds show four key indicators in the country (in bold) compared with its income-group average. If data are missing, the diamond will be incomplete.

Annex 11
Millennium Science Initiative Project
Indicators and Description of the Chilean S&T Sector

Economic, Social, and Scientific Development in Chile. Indicators of social and economic development show Chile to be in the upper range for Latin American countries. By many measures, it is equal with or ahead of the region's larger and more complex economies:

	GNP per capita (1995 USD)	GNP per capita in PPP[8] terms (1995 USD)	Poverty Rate (% of pop.)	Infant Mortality (1995 deaths/ 1000 live births)	Adult Illiteracy (%)	Access to Sanitation (%)
Chile	4,160	9,520	15	12	5	71
Argentina	8,030	8,310	*N/A.*	22	4	89
Brazil	3,640	5,400	29	44	17	73
Colombia	1,910	6,130	7	26	9	70
Mexico	3,320	6,400	15	33	11	70

Source: World Development Indicators, 1997

Chile attracted US$ 4.2 billion in net private capital inflows in 1995, making it the 12th largest recipient in that year among developing countries. (Along with Brazil (US$ 10.4 billion) and Argentina (US$ 7.2 billion), the Southern Cone attracted roughly one-sixth of net private capital inflows in 1995). Chile spends 0.7% of its GDP[9], about US$ 500 million per year, on R&D. The Government's share of spending is about 75%, down from over 90% a decade ago. Resources available to researchers in the form of direct grants to support research, however, total only about US$ 65 million. This come principally from three CONICYT-managed funds (FONDECYT Regular Grants, FONDEF, and FONDAP) and a few other supplemental funds (described in detail below). In S&T indicators, Chile again finds itself comparing favorably to other nations in the region.

	Scientists & Engin./ million pop.	R&D as % of GDP	High-Tech Exports (% of manu. Exports)	Royalty/ License fees receipts per million GNP 1995 (US$)	Royalty/ License fees payments per million GNP 1995 (US$)	% of World's published scientific articles	Articles/ Billions (US$) of GDP
Chile	364	0.7	16	15	743	0.2	6
Argentina	350	0.3	16	7	733	0.4	6
Brazil	391	0.4	16	97	769	0.6	3
Colombia	39	0.1	21	578	420	*N/A.*	*N/A.*
Mexico	226	0.2	35	456	1,936	0.3	2

Sources: World Development Indicators, 1997; NSF 1998 (bibliometric data only)

Two-thirds of articles written by Chilean authors were co-authored, and two-thirds of those were with at least one international co-author. Although the total number of articles is much smaller (700 by Chilean authors in 1995), Chilean *rates* of co-authorship and *rates* of international collaboration are on par with

[8] PPP stand for Purchasing Power Parity. It is used to normalize the buying power of currencies in different areas.
[9] The figure of 0.7% is published both in CONICYT's 1996 S&T Indicators Book and in the 1997 World Development Indicators, which quotes UNESCO surveys as its source. A breakdown of this figure provided to the mission shows that less than 25% of these resources are available as direct competitive funds for research. Close to 50% go to government institutes which are providing basic technological services to industry, and do little research or engineering in the traditional sense.

those of Portugal and the Scandinavian countries. (Note: collaboration varies widely by field and is especially high in astronomy.) Clinical medicine, biomedical research, and biology accounted for over two-thirds of Chilean articles in 1995. While this is above the world average for these fields, it is down from 1981, when they comprised 75% of all publications.

Distribution of Chilean Publications by Field (%)

Field	1981	1989	1995
Clinical Medicine	45	44	41
Biomedical Research	20	17	14
Biology	11	11	12
Chemistry	11	12	11
Physics	3	5	8
Earth & Space Sciences	8	5	9
Engineering & Technology	2	3	2
Mathematics	1	3	3

Source: ISI data published in NSF, 1998

By far the greatest amount of cooperation in articles was with US scientists. Collaboration with authors from the US, UK, Canada, Germany, or France was three times more common than with authors from Argentina, Brazil, or Mexico (an average per year of 11 collaborations versus 3.3 from 1991-95). For the period of 1992-96, the citation impact index for Chilean articles in was the highest in Latin America.

The main source of funding for research is the Consejo Nacional de Investigación Científicas (CONICYT). The principal CONICYT programs listed below:

Principal CONICYT Research Funding Programs

FONDECYT	Makes grants on average US$ 30,000 per year for 3 years to approximately 300 researchers per year. Total annual budget of about US$ 37 million annually. Does not pay the full cost of overhead to universities, or for graduate research assistants, or for post-doctoral fellows
Fondecyt: "Lineas Complementarias"	A program designed to encourage joint research. Researchers from the same faculties only may submit joint proposals. Average funding level per investigator is higher than "regular" FONDECYT grants, but recipients may not simultaneously hold both types. Joint research outside of faculties is not eligible for support. Approximately 20 grants of US$ 100--200 thousands per year are made.
FONDEF	10-20 grants per year for applied or technologically focused research in collaboration with industry. A 22% counterpart contribution—cash or in-kind resources--from a private firm is mandatory. Average grant size is roughly US$ 400,000 per year for up to 3 years.
FONDAP	Supports a network of researchers in two areas: marine biology and applied mathematics. Each discipline receives 1.2 million per year, which is distributed, among a group of researchers with relatively few bureaucratic constraints. Competition for resources is not open; researchers must be invited to apply. Plans to add two more disciplines to FONDAP are underway.
Presidential Fellows	Supports 40 individuals at an average of US$ 110,000 per year for up to 3 years. Open to all fields. Approximately 15 grants per year selected by an international review committee from about 100 applications

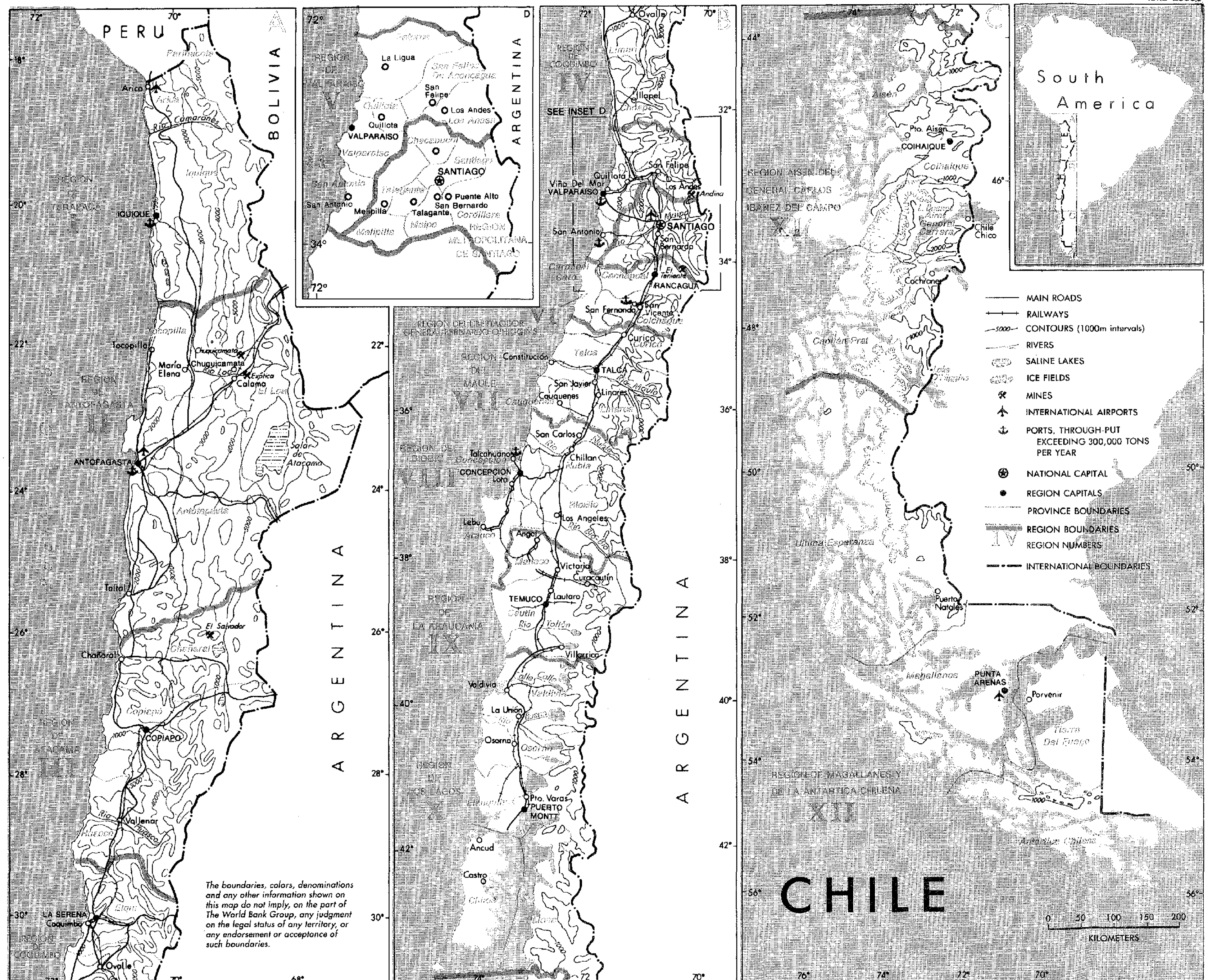
Ph.D./M.A. Scholarships	Cover living expenses for graduate students. All candidates must have been accepted by a program prior to applying, but only 50% of applicants receive grants. 50 per year given at roughly US$ 12,000 each. Support for M.A.'s is more selective than for Ph.D.'s, and only available for programs (engineering, for example) in which no Ph.D. program exists.
Thesis Scholarships	Additional support from CONICYT to Ph.D. students to support their dissertations. Roughly 40-50 grants per year at US$ 11,000 each.

Non-CONICYT support to researchers at universities essentially comes from international sources, such as the EU, and is confined to the top researchers. A large amount of federal support to S&T is absorbed by government technological institutes, which are seen more as basic technological service providers for industry than as "R&D" institutions. FONTEC funds a limited amount of R&D within firms and technology transfer. Finally, the Fundación Chile is a private foundation that promotes technology development in the private sector. With a relatively modest endowment of US$ 50 million, it has played the role of catalyst to some of the country's most successful expansion into higher value added export markets (such as Salmon and Wine). budget with estimated costs of expenditures to be incurred in the execution of the proposed investigation. These costs include equipment, infrastructure, salaries for researchers and post-docs, fellowships, information resources and operating expenses, such as consumables, travel expenditures, and office supplies. Science Institutes (SI) and Science Nuclei (SN) will be selected through periodic, highly selective competitions under a set of rules established by the Program Committee (this Committee will be integrated by internationally recognized scientists). *Grant Agreements* for grants expected to range between US$200.000 and US$2 million will be signed between the Ministry of Planning (where the IMU operates) and the legally established Institutes and Nuclei, or the University where the SI or SN operates, or the PI representing an association which is processing its juridical personality. This process assures high standards of "quality at entry" for the projects to be financed under the fund. The Science Institutes and Nuclei are modeled after the already established Presidential Chairs in Chile. This model has the approval of *Contraloría General de la República* (see Decree No. 285 for the Presidential Chairs in the project files).

Given the sophistication of the research work where equipment and expertise are unique in nature, PIs will use **direct contracting of scientific equipment and other goods**, regardless of value, whenever the equipment or goods are of a proprietary nature or must be procured from a particular supplier as a condition of a performance guarantee [Clause 3.7 (c) and (d) of the Guidelines] according to what was established in the budget of the application's work program and the grant agreement. Other procurement of goods will follow **National Shopping or International Shopping** procedures. **Civil works** can be carried out for rehabilitation / construction of research facilities (including laboratories) not to exceed 25% of the total of the grant. Civil works estimated to cost more than US350,000 shall be procured using NCB procedures; civil works estimated to cost up to US$350,000 shall be procured by obtaining at least three quotations from qualified local contractors. Contracting of **Consultants:** Institutes and Nuclei will contract very specific research

MAP SECTION

IBRD 25555



FEBRUARY 1994